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Sodium Hydroxide Preliminary Source Assessment

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SODIUM HYDROXIDE PRELIMINARY SOURCE ASSESSMENT

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A preliminary source assessment of industries with sodium hydroxide emissions is presented. Brief descriptions of these industries and processes that emit sodium hydroxide are given. Sodium hydroxide emissions data that were used in the Human Exposure Model (HEM) are contained in this report. This Model is used by EPA's Pollutant Assessment Branch to evaluate health risks from various pollutants. Sodium hydroxide emission data were primarily obtained from the States of Kentucky, New Jersey, New York and Texas.

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Emission Standards Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park NC 27711

February 1988

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SODIUM HYDROXIDE
PRELIMINARY
SOURCE ASSESSMENT

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1.0 INTRODUCTION

1.1 INTRODUCTION

The purpose of this project was to identify and characterize the major air emission sources of sodium hydroxide (NaOH) in a preliminary source assessment (PSA). The stack parameters and NaOH emissions that are contained in this PSA for various industries are used as inputs to the Human Exposure Model (HEM) by EPA's Pollutant Assessment Branch to determine ambient concentrations of sodium hydroxide. Details on HEM are contained in "User's Manual for the Human Exposure Model," (EPA-450/5-86-001). Along with this PSA and the resultant ambient HEM modelling, a preliminary health assessment of sodium hydroxide was prepared by EPA's Environmental Criteria and Assessment Office. This assessment is described in "Summary Review of Health Effects Associated with Sodium Hydroxide," (ECAO-R-135). With the preliminary source and health assessments and HEM modelling results, EPA determines if air emissions of sodium hydroxide may pose a significant health risk. If so, a much more detailed study is undertaken to further evaluate the emissions and health risks to determine if sodium hydroxide should be regulated as a hazardous air pollutant under Section 112 of the Clean Air Act.

To develop this preliminary source assessment, numerous sources were used. A literature search provided some references that help identify industries that use sodium hydroxide as well as descriptions of the manufacture of sodium hydroxide (caustic soda). To identify States that presently regulate sodium hydroxide, telephone calls were made to all EPA regional air toxic contacts. Numerous State agencies were then contacted to obtain information on their regulations. Also, the States of Kentucky, New Jersey, New York, and Texas provided computer printouts on NaOH emission estimates. These estimates were the basis of the inputs to the Human Exposure Model. State agency and plant personnel in each industry were contacted to verify these estimates and to obtain information on processes and emission control equipment. At least one trade association in each industry was called to determine how widely NaOH is used by the industry as well as for process information. These associations, as well as the Duns Electronic Yellow Pages help provide plant listings. Information was retrieved from the

National Air Toxics Information Clearinghouse (NATICH) database to identify any plant that is a major emission source of sodium hydroxide but was not identified by printouts from the States. The National Environmental Data System (NEDS) data base was used to determine stack parameters for various kraft pulp mills. Information on sodium hydroxide spills is contained in the Acute Hazardous Events Data Base and was obtained from EPA's Air and Energy Research Laboratory. Also, a National Inspection Summary Report for sodium hydroxide was received from the Occupational Safety and Health Administration (OSHA).

This report contains eleven chapters. The next chapter describes uses and properties of sodium hydroxide. Also, a summary of those plants that are estimated to have sodium hydroxide emissions greater than 10,000 lbs/yr is presented. Information from the Acute Hazardous Events data base and OSHA is also given. Regulations for those States with sodium hydroxide emission limits are also given in Chapter 2. The next seven chapters summarize each industry which has at least one plant with estimated annual NaOH emissions to be greater than 10,000 pounds. A list of plants in each industry along with process and emission information and the HEM inputs for plants in the industries is given. Chapter 10 summarizes plants with sodium hydroxide emissions greater than 1,000 lb/yr but with no plants in their SIC codes with emissions greater than 10,000 lb/yr. Chapter 11 discusses sodium hydroxide (caustic soda) manufacturing plants, and the processes used at these plants as well as estimates of sodium hydroxide emissions from these plants.

2.0 SUMMARY

2.1 SODIUM HYDROXIDE PROPERTIES

Sodium hydroxide (caustic soda) is a white, deliquescent, translucent solid with a crystalline structure. It has a specific gravity of 2.13, a melting point of 318°C and boiling point of 1390°C. It dissolves readily in water evolving heat to form a colorless solution.[1,2] Vapor pressures of various caustic soda solutions are shown in Figure 2-1.

According to an article critiquing the U.S. occupational standard for sodium hydroxide, caustic soda is highly reactive in the atmosphere.[3] Properties of the sodium hydroxide aerosols, such as the chemical composition, mass concentration, particle size distribution, and its phase, depend on its reactions with carbon dioxide, water, and the relative humidity. These interactions produce solid or liquid particles which may be entirely one or several compounds. Whether caustic soda is a solid or liquid, the following reaction takes place:

$$2NaOH+CO_2 \text{ ---> } Na_2CO_3+H_2O$$

Depending on the size of the sodium hydroxide particle and the relative humidity, the NaOH will convert to sodium carbonate within seconds to minutes. More information on these reactions is contained in References 3-5.

2.2 USES OF SODIUM HYDROXIDE

As shown by the printouts on sodium hydroxide emission estimates received from four State Agencies, sodium hydroxide (caustic soda) is used in a wide variety of industries. In particular, caustic soda is used for metal cleaning and electroplating in numerous SIC codes. Table 2-1 gives the end use by industry in 1982 for sodium hydroxide.

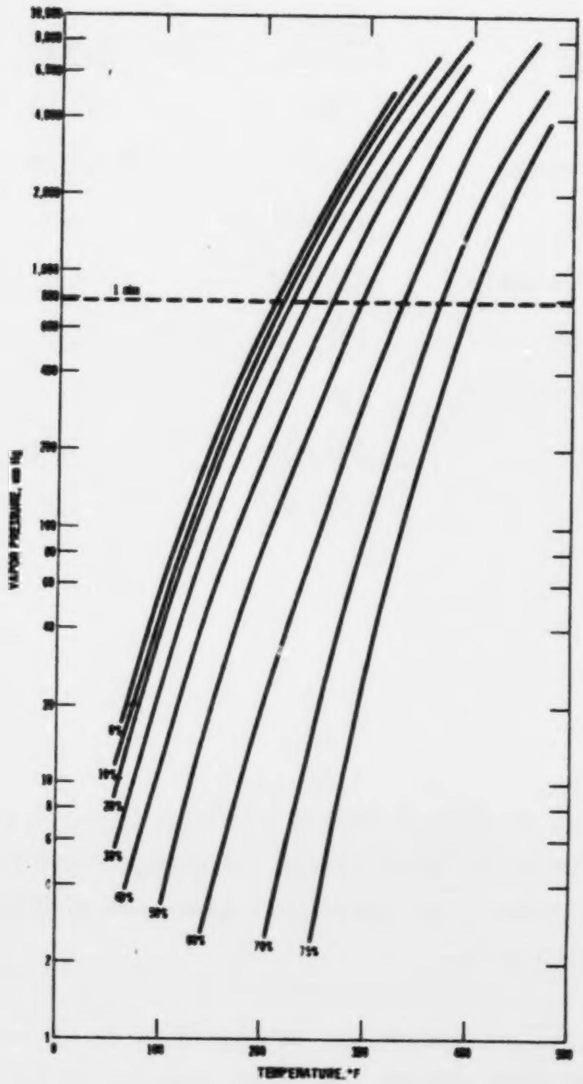

Figure 2-1. Vapor Pressures of Various Caustic Soda Solutions[2]

TABLE 2-1. 1982 CAUSTIC SODA USES[6]

Industry	Amount (10^3MT)	Percent
Chemicals	3,900	48-53
Pulp and Paper	2,070	26-28
Petroleum	483-493	6-7
Soap, Detergents	412-477	6
Cellulosic	185	2-3
Cotton Mercerizing	109	1
Other	187-812	3-10
	7,350-8,050	100

Some other uses of caustic soda are to neutralize acids and the production of sodium salts in petroleum refining, in the production of viscose rayon, cellophane, and plastics. Some uses of NaOH are further described in Chapters 3-10.

In 1986, caustic production was estimated to be more than 11 million tons as 100 percent NaOH with an operating capacity of 12.7 million tons. In 1986, two large producers reduced their production capacity significantly but the long term growth rate will probably continue to be 2-3 percent per year.[8] Information on the historical production of caustic soda and a list of U.S. manufacturing plants is contained in Chapter 11 - NaOH Industry.

Large consumers of caustic soda usually purchase and store caustic soda at a NaOH concentration of 50 or 73 percent. Most users prefer the 50 percent product due to ease in handling. A rayon-grade caustic soda is also produced as a higher quality, more uniform product. Solid caustic is shipped in drums or is processed to produce a flake product.[9]

2.3 NaOH EMISSIONS

Table 2-2 shows those 15 plants in numerical order with sodium hydroxide emissions greater than 10,000 lb/yr as estimated by State Agencies or in the case of the kraft pulp plants, by EPA. As shown in the Table, 9 of these 15 plants are kraft pulp mills. As noted in Chapter 3, HEM inputs were developed for 10 kraft mill plants that represent the range in capacity in these plants. All but 1 of the 10 plants (one of the smallest capacities) exceeded 10,000 lb/yr of emissions by a wide margin. It is reasonable to assume that most of the 123 kraft pulp mills exceed 10,000 lb/yr of sodium hydroxide emissions by a sizeable amount. Also, caustic soda emissions from some plants in the other SIC codes mentioned in Table 2-2 should exceed 10,000 lb/yr but the number of these plants was not determined in this preliminary study.

Based on reviewing computer printouts submitted by State agencies and discussions with plant and State agency personnel, sodium hydroxide emission estimates were revised. In some cases, the revised estimates were much lower. Initial emission estimates for 10 industries that were above 10,000 lb/yr were revised to much lower amounts. These industries with the original estimates and the rationale for the revised estimates follows.

1. SIC 2818 - Industrial Inorganic Chemicals. Monsanto-Logan Township, NJ. Original estimate - 16,000 lb/yr. Very little emissions are expected as most estimated emissions come from storage tanks. The revised estimate was supported by calculating emissions based on equations in AP-42 for petroleum storage tanks and by conversations with State Agency personnel.

TABLE 2-2. PLANTS WITH ESTIMATED SODIUM HYDROXIDE EMISSIONS GREATER THAN 10,000 LB/YR.

SIC CODE	INDUSTRY	PLANT	LOCATION	NaOH EMISSIONS (lb/yr)	PROCESS	CONTROL EQUIPMENT
2611	Kraft Pulp	Longview Fiber	Longview, WA	252,000	4 Smelt Dissolving Tanks	Mist Eliminator
2611	Kraft Pulp	Great Southern Paper	Cedar Springs, GA	154,000	3 Smelt Dissolving Tanks	Wet Scrubber
2611	Kraft Pulp	Union Camp	Savannah, GA	119,000	4 Smelt Dissolving Tanks	Wet Scrubber
2082	Beer Manuf.	Miller Brewing	Fulton, NY	106,000	2 Bottle Washing Systems	None
2611	Kraft Pulp	International Paper	Camden, AR	102,000	3 Smelt Dissolving Tanks	Spray Tower, 2 Water Curtains
3714	Auto Carburetor	Rochester Products	Rochester, NY	67,000	Plating Tanks, Caustic Cleaning Tanks, other processes	None
2611	Kraft Pulp	Weyerhaeuser	Plymouth, NC	65,000	2 Smelt Dissolving Tanks	Mist Eliminator
2611	Kraft Pulp	Champion Int.	Pensacola, FL	53,000	2 Smelt Dissolving Tanks	Venturi Scrubber
2611	Kraft Pulp	Georgia-Pacific	Port Hudson, LA	52,000	3 Smelt Dissolving Tanks	Unknown
2611	Kraft Pulp	James River	Butler, AL	42,000	3 Smelt Dissolving Tanks	Wet Scrubber
2611	Kraft Pulp	Crown Zellerbach	Bogalosa, LA	33,000	1 Smelt Dissolving Tank	Mist Eliminator
3471	Plating	Monroe Plating	Rochester, NY	22,000	2 Plating Tanks, 3 Caustic Cleaning Tanks	None

TABLE 2-2. (Continued)

SIC CODE	INDUSTRY	PLANT	LOCATION	NaOH EMISSIONS (lb/yr)	PROCESS	CONTROL EQUIPMENT
2869	Industrial Organic Chemicals	Elan Chemical	Newark, NJ	15,000	Preheater, Premix Tank	None
2841	Soap, Detergents	Chemed	E. Rutherford, NJ	14,000	Storage, 3 Batch Kettles	None
2542	Metal Partitions	Ferro Merchandising	Union, NJ	11,000	5 Electroclean Tanks, 2 Soak Clean Tanks	None

2. SIC 2911 - Petroleum Refining. Exxon - Linden, NJ. Original estimate - 88,000 lb/yr of caustic solution emissions; Chevron - Perth Amboy, NJ - 26,000 lb/hr; Mobil - Greenwich Township, NJ - 12,000 lb/yr. Nearly all emissions came from storage tanks so emissions are now considered to be minor. See rationale under 1.

3. SIC 3229 - Press and Blown Glass. Owens-Illinois - Vineland City, NJ. Original estimate - 77,000 lb/yr from borosilicate glass furnaces. Plant personnel stated that caustic soda is not used and process descriptions from the literature does not indicate any use of caustic soda in this industry. State personnel confirmed that no sodium hydroxide is used at the plant.

4. SIC 3312 - Blast Furnaces. BSC Bar Products - Lackawanna, NY. Original estimate - 20,000 lb/yr based on 260 days/yr operating metal cleaning process at a bar mill coil pickling facility. Plant personnel stated the process only operates 8 hr/day, 20 days/yr so revised estimate should be 1,500 lb/yr.

5. SIC 3339 - 1° Non-Ferrous Metals. ASARCO - Newark, NJ. Original estimate - 38,000 lb/yr. Both State and company personnel stated that the plant has been shut down for 2 years with no plans for reopening.

6. SIC 3463 - Nonferrous Forgings. Intercontinental Manufacturing - Garland, TX. Original estimate - 25,000 lb/yr. State agency personnel checked and stated that this was the amount of caustic soda used as stated in a 1980 Inventory Sheet. According to the State agency, NaOH emissions should be 240 lb/yr.

7. SIC 3544 - Tools and Special Dies. Alliance Metal - Gates, NY. Original estimate - 12,000 lb/yr. According to plant personnel, plant uses 60 lb/yr of caustic soda so emissions will be less than 60 lb/yr.

8. SIC 3572 - Typewriters. IBM - Lexington, KY. Original estimate - 19,000 lb/yr from electroless nickel plating. State personnel stated that this process discontinued operations in 1985 and was dismantled in 1986. Emission estimates for each of four plants in SIC 357 are below 2,900 lb/yr.

9. SIC 4231 - Trucking Terminal Facilities. P.D. Oil - Bayonne, NJ. Original estimate - 32,000 lb/yr. All emissions are from storage tanks. Revised estimate is minor. See rationale under 1.

10. SIC 5172 - Petroleum Products, NEC. Gordon Terminal - Bayonne, NJ. Original estimate - 13,000 lb/yr. All emissions are from storage tanks. Revised emission estimate is minor. See rationale under 1.

2.4 STATE REGULATIONS

This section describes existing State regulations regarding industrial processes that use sodium hydroxide. In general, these processes have to comply with particulate emission standards which are based on process weight equations. Two equations commonly used by State agencies are given below:

$$E = 4.2p^{0.67}; \quad p \leq 30$$
$$E = 55p^{0.11} - 40; \quad p > 30$$

Where "p" is the tons of material processed per hour.

In addition, seven States have additional regulations specific to sodium hydroxide. Ambient modelling is performed by these State Agencies to verify that these regulations are met. A summary of these State regulations follows. Allowable emission limits for sodium hydroxide vary from 2 - 2,200 ug/m^3 depending on the State and the corresponding time period which varies from 30 minutes to a year.

Connecticut - (New and Existing Sources). Sodium hydroxide is considered a Group III pollutant (slightly toxic).

- 40 ug/m^3 (8 hr average)
- 200 ug/m^3 (30 min average).

Kentucky - (New and Existing Sources)

$$E_{AL} = E_{AC} \times \frac{TAL}{C}$$

E_{AL} = Allowable emission limit in pounds per hour.

E_{AC} = Actual emission rate in pounds per hour

TAL = Threshold ambient limit. For sodium hydroxide,

$$TAL = \frac{8 \text{mg/m}^3}{\text{Operating hrs per wk } (\geq 40)}$$

C = Maximum ground level ambient air concentration estimated by modelling in mg/m^3.

If sodium hydroxide emissions for the source are less than 3.583 x 10^{-4} lbs/hr then the source does not have to comply with these equations.

Nevada - (New and Existing Sources)

- 48 ug/m^3 (8 hr. average)

Sodium hydroxide is considered a Level III pollutant (Toxic Hazardous Air Contaminant).

New York - (New and Existing Sources)

- 40 ug/m^3 (Annual Ambient Level). Sodium hydroxide is considered a low toxic air pollutant.

South Carolina - (New Sources Only)

- 20 ug/m^3 (24 hr. average). Sodium hydroxide is considered to be moderately toxic.

Texas - (New and Existing Sources)

- 20 ug/m^3 (30 min. average)
- 2 ug/m^3 (annual average)

Virginia - (New Sources Only)

- 17 ug/m^3 (24 hr. average)

2.5 WORKER EXPOSURE

2.5.1 Worker Exposure Standards

The current Federal standard for sodium hydroxide is 2 mg/m^3 as a time weighted average during an 8-hour period. This standard is much higher than some of the ambient levels established by State agencies. This standard was recommended by the Occupational Safety and Health Administration (OSHA) and is based on the 1968 American Conference of Governmental Industrial Hygienist's (ACGIH) Threshold Limit Value. In 1986-87, ACGIH recommended that 2 mg/m^3 not be exceeded at any time.[10] The National Institute for Occupational Safety and Health (NIOSH) recommended this same level not be surpassed in a 15 minute period.[11] Six other countries have recommended standards for exposure to sodium hydroxide in the workplace. These standards are shown on Table 2-3. All standards are ceilings, that is, should not be exceeded at any time. More information on these standards is contained in references 3 and 11.

TABLE 2-3. NaOH WORKPLACE STANDARDS[11]

Country	Pollutant	Standard (mg/m^3)
Finland	NaOH	2
West Germany	NaOH	2
Yugoslavia	NaOH	2
Rumania	Hydroxides (alkaline)	1
Bulgaria	Alkalies	0.5
USSR	" aersols (as NaOH)	0.5

2.5.2 Worker Exposure Data

Table 2-4 summarizes data in descending numerical order received from the Occupational Safety and Health Administration on a National Inspection Summary Report of Sodium Hydroxide that includes all Federal inspections between June 1, 1979, to October 31, 1986.[12] Any sample value on this report which is greater than or equal to 0.5 mg/m^3 is included in the Table. According to the National Institute for Occupational Safety and Health, 150,000 workers are estimated to be potentially exposed to NaOH.[11]

TABLE 2-4. NATIONAL INSPECTION SUMMARY REPORT - OSHA[12]

SIC CODE	INDUSTRY	PLANT	LOCATION	JOB TITLE	NO. OF PEOPLE EXPOSED	NO. OF SAMPLES	VALUE (mg/m^3)
3471	Electroplating	Mycor Metal Finishing	Rochester, NY	Unknown	1	1	8.0
1541	Industrial Building	Ethyl Corp.	Pasadena, TX	Burner Operator	4	TWA[a]	1.44-6.81
3334	Primary Aluminum	Kaiser Al	Ravenswood, WV	Bath Mill Operator	3	TWA	3.77
2842	Speciality Cleaning	Chemix Corp.	Berea, OH	Unknown	1	1	3.6
2841	Soap & Detergents	Time Chemicals	Chicago, IL	Mixer	8	TWA	3.4
2869	Industrial Organic Chemicals	Continental Products	Odessa, TX	Warehouseman	2	TWA	2.6
2842	Speciality Cleaning	Can-Tol	Philadelphia, PA	Unknown	1	3	2.4
2810	Industrial Inorganic Chemicals	Harshaw Chemical	Gloucester City, NJ	Process Man	4	TWA	1.73
2841	Soap & Detergents	Time Chemicals	Chicago, IL	Mixer	1	TWA	1.6
3471	Electroplating	Logan Finishing	Lakeview, OH	Anodizer	4	TWA	1.4
3069	Fab. Rubber Production	Pioneer Industrial Prod.	Hillard, OH	Chlorinator	6	TWA	0.85
3621	Motors & Generators	General Electric	Tiffin, OH	Mold Repairman	2	TWA	0.74

---

[a] Time Weighted Average

TABLE 2-4. (Continued)

SIC CODE	INDUSTRY	PLANT	LOCATION	JOB TITLE	NO. OF PEOPLE EXPOSED	NO. OF SAMPLES	VALUE (mg/m^3)
2841	Soap & Detergents	H. Kohnstamm	Chicago, IL	Chemical Mixer	2	TWA	0.71
2842	Speciality Cleaning	Can-Tol	Philadelphia, PA	Mixer	2	TWA	0.64
2841	Soap & Detergents	H. Kohnstamm	Chicago, IL	Chemical Mixer	2	TWA	0.63
3561	Pumps	Thompson Pump	Okmulgee, OK	Dipper	1	TWA	0.63
2542	Metal Partitions	Ferro Merchandising	Union, NJ	Hoist Operator	1	TWA	0.61
2841	Soap & Detergents	Time Chemicals	Chicago, IL	Operator Mixer	1	TWA	0.60
3471	Electroplating	Poly Metal Finishing	Springfield, MA	Loading Foreman	29	TWA	0.56
2841	Soap & Detergents	Time Chemicals	Chicago, IL	Filler Mixer	3	TWA	0.50

2.6 SODIUM HYDROXIDE EMISSIONS - SHORT TERM RELEASE

Three events are reported in the Acute Hazardous Events database for the period 1980 - mid 1985 that relate to sodium hydroxide air emission releases. All occurred during transit of solid caustic soda. No significant problems resulted. There are numerous examples of spills of caustic soda solutions but little if any resulting atmospheric emissions are reported in this database.[13]

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3.0 THE KRAFT PULPING INDUSTRY

3.1 INDUSTRY DESCRIPTION

Table 3-1 shows the 123 kraft pulp mills operating in the United States. These mills are concentrated in the Southeast, Pacific Northwest, and New England regions. As shown in Table 3-1, the capacity of these plants ranges from 180 - 2,850 tons per day of pulp and they operate close to capacity.

TABLE 3-1.

SUMMARY OF KRAFT MILLS IN THE UNITED STATES[1,2]

STATE	COMPANY	LOCATION	Kraft Production Capacity (tpd)	Avg. Daily Production (tpd)
Alabama	Container Corp.	Brewton	1334	1100
	James River Corp.	Butler	1000	1000
	Alabama River Pulp Co.	Claiborne	1000	1000
	Kimberly-Clark Corp.	Coosa Pines	850	854
	Champion International Corp.	Courtland	1393	1300
	Gulf State Paper Corp.	Demopolis	500	500
	Allied Paper, Inc.	Jackson	600	600
	International Paper Co.	Mobile	1072	1035
	Scott Paper Co.	Mobile	1450	1400
	Union Camp Corp.	Montgomery	2050	2220
	Alabama Kraft Co.	Phenix City	1100	1000
	MacMillon Bloedel, Inc.	Pine Hill	1100	1075
	Hammermill Papers Group	Selma	1100	1100
Arizona	Southwest Forestry Industries,Inc.	Snowflake	700	700
Arkansas	Nekoosa Papers Inc.	Ashdown	1400	1350
	International Paper Co.	Camden	801	723
	Georgia-Pacific Corp.	Crossett	1500	1400
	Potlatch Corp.	Cypress Bend	525	450
	Arkansas Kraft Corp.	Mowilton	780	800
	International Paper	Pine Bluff	1193	1112
	Weyerhaeuser Co.	Pine Bluff	300	280
California	Simpson Paper Co.	Anderson	225	225
	Fiberboard Corp.	Antioch	750	600
	Simpson Paper Co.	Fairhaven	640	640
	Louisiana-Pacific Corp.	Samoa	600	600

TABLE 3-1.

SUMMARY OF KRAFT MILLS IN THE UNITED STATES (cont'd)

STATE	COMPANY	LOCATION	Kraft Production Capacity (tpd)	Avg. Daily Production (tpd)
Florida	Container Corp of Am.	Jacksonville	1400	1500
	Alton Packaging Corp.	Jacksonville	1400	1470
	Georgia-Pacific Corp.	Palatka	1085	1200
	Southwest Forest Industries,Inc.	Panama City	1450	1400
	Champion International Corp.	Pensacola	1560	1730
	Buckeye Cellulose Corp.	Perry	1000	1100
	St. Joe Paper Co.	Port Saint Joe	1700	1700
Georgia	Federal Paperboard	Augusta	1000	1000
	Brunswick Pulp & Paper Co.	Brunswick	1760	1700
	Great Southern Paper Co.	Cedar Springs	1870	1870
	ITT Rayonier, Inc.	Jesup	1400	1400
	Georgia Kraft Co.	Krammert	2000	1700
	Georgia Kraft Co.	Macon	950	900
	Buckeye Cellulose Corp.	Oglethorpe	860	750
	Stone Container Corp.	Port Wentworth	800	800
	Interstate Paper Corp.	Riceboro	550	525
	Gilman Paper Co.	St. Marys	1200	1225
	Union Camp Corp.	Savannah	2850	3000
	Owens-Illinois Inc.	Valdosta	998	900
Idaho	Potlatch Corp.	Lewiston	1100	1100
Kentucky	Willamette Industries, Inc.	Hawesville	660	600
	Westvaco Corp.	Wickliffe	722	650

TABLE 3-1.

SUMMARY OF KRAFT MILLS IN THE UNITED STATES (cont'd)

STATE	COMPANY	LOCATION	Kraft Production Capacity (tpd)	Avg. Daily Production (tpd)
Louisiana	International Paper Co.	Bastrop	1200	1200
	Crown Zellerbach Corp.	Bogalusa	1300	1260
	Williamette Industries, Inc.	Campti	800	750
	Boise Cascade Corp.	De Ridder	1275	1210
	Stone Container Corp.	Hodge	1400	1400
	International Paper Co.	Mansfield	2050	1430
	International Paper Co.	Pineville	985	975
	Georgia-Pacific Corp.	Port Hudson	1285	1300
	Crown Zellerback Corp.	St. Francisville	495	550
	Manville Forest Products	West Monroe	1400	1728
Maine	Warren Co., S.D.	Hinckley	800	900
	International Paper Co.	Jay	1200	1200
	Lincoln Pulp & Paper Co.,Inc.	Lincoln	350	340
	James River Corp.	Old Town	600	600
	Boise Cascade Corp.	Rumford	950	630
	Warren Co., S.D.	Westbrook	295	300
	Georgia-Pacific Corp.	Woodland	800	800
Maryland	Westvaco Corp.	Luke	Unk.	794
Michigan	Mead Corp.	Escanaba	800	600
	Warren Co., S.D.	Muskegon	230	250
Minnesota	Potlatch Corp.	Cloquet	490	475
	Boise Cascade Corp.	International Falls	365	380

TABLE 3-1.

SUMMARY OF KRAFT MILLS IN THE UNITED STATES (cont'd)

STATE	COMPANY	LOCATION	Kraft Production Capacity (tpd)	Avg. Daily Production (tpd)
Mississippi	Georgia-Pacific Corp.	Monticello	1995	1700
	International Paper Co.	Moss Point	750	661
	International Paper Co.	Natchez	1104	1112
	International Paper Co.	Vicksburg	1181	1200
	Leaf River Forest Products,Inc.	New Augusta	Unk.	1000
Montana	Champion International Corp.	Missoula	1900	1900
New Hampshire	James River Corp.	Berlin	800	800
New York	International Paper Co.	Ticonderoga	530	530
North Carolina	Champion International Corp.	Canton	1440	1390
	Weyerhaeuser	New Bern	700	725
	Weyerhaeuser	Plymouth	1480	1405
	Federal Paper Board Co.	Riegelwood	2000	2030
	Champion International	Roanoke Rapids	1100	1050
Ohio	Mead Corp.	Chillicothe	600	600
Oklahoma	Weyerhaeuser	Valliant	1600	1650
Oregon	Williamette Industries, Inc.	Albany	580	600
	Crown Zellerbach Corp.	Clatskanie	775	836
	International Paper Co.	Gardiner	850	600
	Pope & Talbot Pulp, Inc.	Halsey	400	350
	Boise Cascade Corp.	St. Helens	1000	965
	Weyerhaeuser Co.	Springfield	1090	1090
	Georgia-Pacific Corp.	Toledo	1140	1090

TABLE 3-1.

SUMMARY OF KRAFT MILLS IN THE UNITED STATES (cont'd)

STATE	COMPANY	LOCATION	Kraft Production Capacity (tpd)	Avg. Daily Production (tpd)
Pennsylvania	Penntech Papers Inc.	Johnsonburg	220	180
	Appleton Papers Inc.	Roaring Springs	180	190
	P.H. Glatfelter Co.	Spring Grove	575	500
South Carolina	Westvaco Corp.	Charleston	2435	2050
	Stone Container Corp.	Florence	1400	1400
	International Paper Co.	Georgetown	1608	n.a.
	Bowater Carolina Co.	Catawba	1050	1150
	Union Camp Corp.	Eastover	700	600
Tennessee	Bowater Southern Paper Co.	Calhoun	690	700
	Tennessee River Pulp & Paper Co.	Counce	1600	1500
Texas	Temple - Eastex Inc.	Evadale	1550	1520
	Champion International Corp.	Houston	650	630
	Champion International Corp.	Lufkin	400	400
	Champion International Corp.	Pasadena	850	750
	International Paper Co.	Texarkana	1288	1215
	Owens-Illinois Inc.	Orange	1200	1150
Virginia	Westvaco Corp.	Covington	1376	1050
	Union Camp Corp.	Franklin	1950	1950
	Stone Container Corp.	Hopewell	1000	900
	Chesapeake Corp.	West Point	1400	1920
Washington	Crown Zellerbach Corp.	Camas	810	810
	Weyerhaeuser Co.	Everett	395	385
	Longview Fibre Co.	Longview	2800	2000
	Weyerhaeuser Co.	Longview	800	750
	Port Townsend Paper Corp.	Port Townsend	450	445
	Simpson Paper Co.	Tacoma	1040	1090
	Boise Cascade Corp.	Wallula	776	690
Wisconsin	Thilmany Pulp & Paper Co.	Kaukauna	430	400
	Mosinee Paper Corp.	Mosinee	195	220
	Nekoosa Papers Inc.	Nekoosa	335	335
	Consolidated Papers, Inc.	Wisconsin Rapids	577	515

3.2 PROCESS DESCRIPTION

3.2.1 General

Manufacturing of paper and paper products is a complex process which is carried out in two distinct phases: the pulping of the wood and the manufacture of the paper. Pulping is the conversion of fibrous wood into a "pulp" material suitable for use in paper, paperboard, and building materials. Of the two phases involved in paper-making, the pulping process is the largest source of air pollution. The kraft or sulfate pulping process produces over 80 percent of the chemical pulp produced annually in the United States. The remaining 20 percent of the chemical pulp is produced by the sulfite and neutral sulfite semi-chemical (NSSC) processes.[3]

Pulp wood can be considered to have two basic components, cellulose and lignin. The fibers of cellulose, which comprise the pulp, are bound together in the wood by the lignin. To render cellulose usable for paper manufacture, the pulping process must first remove the lignin.

The kraft pulping process is shown in Figure 3-1. In this process, wood chips are cooked (digested) at an elevated temperature and pressure in "white liquor", which is a water solution of sodium sulfide (Na_2S) and sodium hydroxide ($NaOH$). The white liquor chemically dissolves lignin from the wood. The remaining cellulose (pulp) is filtered from the spent cooking liquor and washed with water. Usually, the pulp then proceeds through various intermittent stages of washing and possibly bleaching, after which it is pressed and dried into the finished product (paper).

The balance of the kraft process is designed to recover the cooking chemicals and heat. Spent cooking liquor and the pulp wash water are combined to form a weak black liquor which is concentrated in a multiple-effect evaporator system to about 55 percent solids. The black liquor is then further concentrated to 65 percent solids in a direct-contact evaporator, which evaporates water by bringing the liquor in contact with the flue gases from the recovery furnace, or in an indirect-contact concentrator. The strong black liquor is then fired in a recovery furnace. Combustion of the organics dissolved in the black liquor provides heat for generating process steam and converting sodium sulfate (Na_2SO_4) to Na_2S. To make up for chemicals lost in

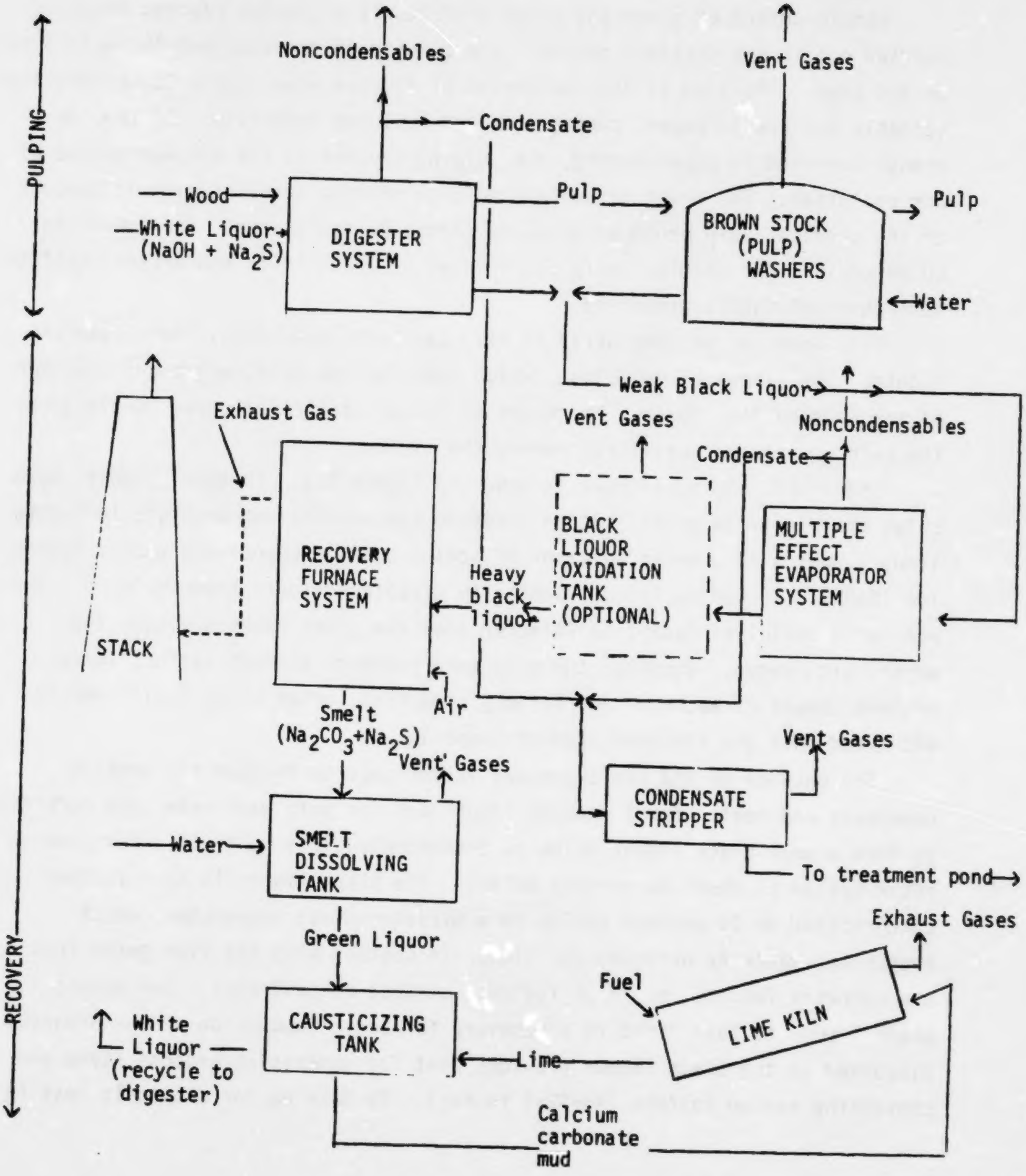
PULPING
RECOVERY
Noncondensables
Condensate
Vent Gases
Wood
White Liquor (NaOH + Na_2S)
DIGESTER SYSTEM
Pulp
BROWN STOCK (PULP) WASHERS
Pulp
Water
Weak Black Liquor
Noncondensables
Condensate
Vent Gases
Exhaust Gas
STACK
RECOVERY FURNACE SYSTEM
Heavy black liquor
BLACK LIQUOR OXIDATION TANK (OPTIONAL)
MULTIPLE EFFECT EVAPORATOR SYSTEM
Air
Smelt (Na_2CO_3+Na_2S)
Vent Gases
Vent Gases
CONDENSATE STRIPPER
To treatment pond
Water
SMELT DISSOLVING TANK
Green Liquor
Exhaust Gases
Fuel
LIME KILN
CAUSTICIZING TANK
Lime
White Liquor (recycle to digester)
Calcium carbonate mud

Figure 3-1. Kraft pulping process [4]

the operating cycle, salt cake (sodium sulfate) is usually added to the concentrated black liquor before it is sprayed into the furnace. Inorganic chemicals present in the black liquor collect as a molten smelt at the bottom of the furnace.

The smelt, consisting of sodium carbonate (Na_2CO_3) and sodium sulfide, is dissolved in water to form green liquor which is transferred to a causticizing tank where quicklime (CaO) is added to convert the sodium carbonate to sodium hydroxide. Formation of the sodium hydroxide completes the regeneration of white liquor, which is returned to the digester system. A calcium carbonate mud precipitates from the causticizing tank and is calcined in a lime kiln to regenerate quicklime.

3.2.2 Specific Process of Interest

As shown in the next section, the only process source estimated to emit sodium hydroxide is the smelt dissolving tank (see Figure 3-2). This cylindrical tank is approximately 10 feet in height and 20 feet in diameter and is located below the recovery furnace hearth.

Molten smelt composed of sodium sulfide and sodium carbonate accumulates on the floor of the recovery furnace and is drained from this furnace through smelt spouts. The smelt is discharged into a water-filled vessel referred to as the smelt dissolving tank. "Green liquor" is formed by the incorporation of the smelt into water through quenching.

Green liquor levels are maintained several feet below the top of the tank to allow for expansion and steam liberation. Contact of the molten smelt with water creates large volumes of steam, which must be vented. High liquor levels result in carryover of liquor droplets and particulate matter into the tank vent system. The tank is agitated with compressed air or mechanical agitation to aid in mixing. The water-cooled smelt spout enters the tank through a doghouse enclosure installed on the top of the tank.

Steam or recirculated green liquor is used in the smelt spout to shatter the smelt before it contacts the liquor surface. Incomplete shattering can result in violent steam explosions as large droplets enter the water and release large quantities of steam. The major causes of

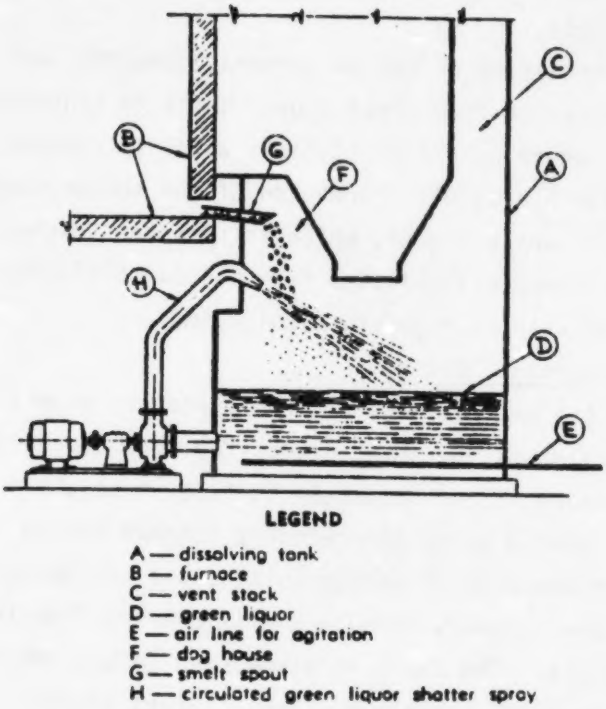
B
G
F
C
A
H
D
E
LEGEND
A — dissolving tank
B — furnace
C — vent stack
D — green liquor
E — air line for agitation
F — dog house
G — smelt spout
H — circulated green liquor shatter spray

Figure 3-2. Smelt dissolving tank with water sprays.[5]

explosions in smelt tanks (which constitute a serious and potentially dangerous problem) are smelt sulfidity, lack of shatter efficiency, lack of smelt reduction efficiency, sodium chloride content, and sodium hydroxide. Temperatures in the smelt spout are between 1600 and 2000°F.[6]

3.3 EMISSIONS

3.3.1 Uncontrolled Emissions

Because of turbulence in the space above the liquor in the smelt dissolving tank, significant amounts of particulate are emitted with the steam. The uncontrolled emission rate from the tank varies greatly depending on quench rate, tank design, exhaust volume, and smelt chemistry. Some data indicate that a strong relationship exists between steam shatter flow and carryover.[6] Uncontrolled emissions from a typical smelt dissolving tank (1000 tons of pulp/day) may be as high as 380 lb/hr [8.0 lb/T Air Dryed Pulp (ADP)].

According to a representative from the National Council of the Paper Industry for Air and Stream Improvement, a trade association for the kraft pulp industry, the only process with sodium hydroxide emissions is the smelt dissolving tank. He estimated that 25 - 50% of the particulate emitted from this tank is sodium hydroxide. The rest of the particulate consists of sodium sulfide and sodium carbonate.[8]

3.3.2 Emission Control Equipment

By proper attention to tank design, steam shatter jet location, steam flow, and vent control, many mills are able to operate with minimum abatement equipment on the smelt dissolving tank stack. The gases from most smelt tanks are vented through demister pads which are fine wire mesh screens about one foot thick. Demister pads are basically low energy scrubbers with collection efficiencies of about 80 percent. Droplets condensing from the gas collect on the screen, and are backflushed with water sprays to the dissolving tank. Several dissolving tanks are equipped with more efficient water scrubbers, such as low pressure drop venturis (6-8 inches of water), packed towers, or cyclones with water sprays.

Efficiencies of these systems are about 95 percent. A few mills combine the dissolving tank gases with the recovery furnace gases, sending both streams to an electrostatic precipitator.[4]

3.3.3 Controlled Emissions

Emission data reported for 29 dissolving tanks range from 0.05 to 2.38 lb/T ADP (equivalent to about 0.009-0.4 gr/dscf) with a median of 1.0 lb/T ADP (equivalent to about 0.17 gr/dscf).[9] Available data reported from a previous survey by EPA are shown in Table 3-2.[9] These data compare the efficiencies of various scrubber systems.

TABLE 3-2. PARTICULATE EMISSIONS FROM VARIOUS SMELT DISSOLVING TANK CONTROL SYSTEMS[9]

Control System	Collection Efficiency %	Emission Rate lb/T ADP	Emission Rate g/kg ADP[a]	Emission Rate gr/dscf[b]
Demister pad	72	0.052	0.03	0.009
	77	0.15	0.08	0.03
	78	0.63	0.32	0.1
	90	2.3	1.15	0.4
	93	1.2	0.60	0.2
	71	1.58	0.79	0.3
Demister pad plus shower	96	0.41	0.21	0.07
Demister pad plus packed tower	92	1.20	0.60	0.2
Packed tower	98	0.05	0.03	0.009

[a] Calculated from emissions in lb/T ADP on the basis of 1.0 lb/T ADP = 0.5 g/kg ADP. ADP = Air Dryed Pulp

[b] Calculated from emissions in lb/T ADP on the basis of 1.0 gr/dscf = 5.76 lb/T ADP.

3.4 HEM INPUTS

Two sets of HEM inputs were developed for the kraft pulp industry. The first set was based on model smelt tanks that were developed in October 1975 to perform a modeling analysis of the ambient air impact of kraft pulp mills. These HEM inputs are shown in Table 3-3. The units were assumed to operate 360 days/year. The yearly production for each of the three model sizes was multiplied by a typical State regulation of 0.5 pounds of particulate matter per ton of unbleached kraft pulp produced to determine the total particulate emitted from each model size. Based on a conversation with NCASI, 25-50 percent of the total particulate is estimated to be sodium hydroxide.[8] Under worst case assumption, 50 percent of the particulate was assumed to be sodium hydroxide and therefore the total particulate emissions were multiplied by 0.5. These calculations are presented in an appendix to this chapter.

The other set of HEM inputs is shown on Table 3-4. These were obtained by selecting plants with various capacity sizes in the kraft pulp industry. Information on these plants was requested from National Emission Data System (NEDS). Sodium hydroxide emissions for smelt tanks in these plants were determined by multiplying the typical States regulation (0.5 lb/ton of pulp) by the yearly production and multiplying by 0.5. If the estimated emissions for these plants, as shown in NEDS, were based on emission test results, these estimates were used and multiplied by 0.5 to determine the amount of sodium hydroxide. These calculations are presented in an appendix to this chapter.

TABLE 3-3.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM MODEL SIZE SMELT DISSOLVING TANKS IN KRAFT PULP PLANTS

SIZE (Tons/Day)	EMISSION TYPE	STACK HEIGHT (m)	CROSS-SECT. AREA[a] (m^2)	STACK DIAMETER (m)	STACK VELOCITY (m/s)	STACK TEMP. (°K)	NaOH EMISSIONS (kg/yr)[b]
500	Stack	53.0	80	1.5	14.6	366	20,500
1000	Stack	53.0	80	1.5	14.6	366	40,900
1500	Stack	53.0	80	1.5	14.6	366	61,000

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[a] Cross-sectional area is defined as the stack height x stack diameter.

[b] Based on 360 days per year operation.

TABLE 3-4.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM SMELT DISSOLVING TANKS AT CERTAIN KRAFT PULP PLANTS

PLANT NAME	STATE	LAT. (deg, min, sec)	LONG. (deg, min, sec)	TOTAL PRODUCT. CAPACITY (TPD)	EMISS. TYPE	STACK HEIGHT (m)	CROSS-SECT. AREA (m^2)	STACK DIAMETER (m)	STACK VELOCITY (m/s)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	EMISSION SOURCE	CONTROL EQUIP.
James River	AL	321325	880107	1000	Stack	37	41	1.1	5.4	352	5,900	Tank 1	None
					"	37	41	1.1	5.4	348	6,400	Tank 2	"
					"	38	42	1.1	4.1	356	6,800	Tank 3	Wet Scrubber
Int. Paper	AR	333733	924919	801	Stack	68	129	1.9	3.9	341	14,000	Tank 1	Spray Tower
					"	46	35	0.76	6.8	356	18,000	Tank 2	Water Curt.
					"	46	35	0.76	8.8	363	14,500	Tank 3	Water Curt.
Simpson Paper	CA	402542	1221600	225	Stack	41	25	0.6	7.8	343	1,400	Tank 1	Wet Scrub.
Champion Int.	FL	303622	871924	1560	Stack	52	62	1.2	7.1	344	7,700	Smelt Tank	Venturi Scrubber
					"	52	62	1.2	7.1	344	16,400		
Great Southern Paper	GA	310949	850537	1870	Stack	49	59	1.2	7.5	347	25,000	Tank 1	Wet Scrub.
					"	49	88	1.8	8.2	333	24,100	Tank 2	" "
					"	76	441	5.8	0.88	450	20,900	Tank 3	" "
Union Camp	GA	320612	810718	2850	Stack	70	105	1.5	3.8	339	8,600	Tank 12	" "
					"	70	105	1.5	4.8	345	10,900	Tank 13	" "
					"	93	223	2.4	6.5	339	34,500	Tank 14A, 14B	" "
Georgia Pacific	LA	303900	911641	1290	Stack	61	67	1.1	9.1	344	14,500	Tank 1	Unknown
					"	61	85	1.4	6.1	361	4,500	Tank 2A	"
					"	61	85	1.4	6.7	361	4,500	Tank 2B	"

TABLE 3-4. (Continued)

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM SMELT DISSOLVING TANKS AT CERTAIN KRAFT PULP PLANTS

PLANT NAME	STATE	LAT. (deg, min, sec)	LONG. (deg, min, sec)	TOTAL PRODUCT. CAPACITY (TPD)	EMISS. TYPE	STACK HEIGHT (m)	CROSS-SECT. AREA (m^2)	STACK DIAMETER (m)	STACK VELOCITY (m/s)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	EMISSION SOURCE	CONTROL EQUIP.
Crown Zellerbach	LA	304237	911930	495	Stack	41	74	1.8	3.7	336	15,000	Tank 1	Mist Elim.
Weyer-haeuser	NC	351246	770653	700	Stack	69	97	1.4	5.8	336	14,800	Tank 1	" "
					"	69	97	1.4	5.8	336	14,800	Tank 2	" "
Longview Fibre	WA	402542	1221600	2800	Stack	38	42	1.1	7.3	324	14,600	Tank 11	" "
					"	48	58	1.2	21.1	326	38,900	Tank 15	" "
					"	58	70	1.2	10.8	335	11,600	Tank 18	" "
					"	57	80	1.4	14.6	329	49,500	Tank 19	" "

APPENDIX - CHAPTER 3 - KRAFT PULP

Based on telephone conversation with Russ Blosser, NCASI, the only emission sources of NaOH at kraft pulp mills are smelt dissolving tanks. Mr. Blosser estimated that 25-50 percent of particulate is NaOH. For worst case analysis, use 50 percent.

Typical State Standard for PM at Smelt Dissolving Tanks - 0.5 lb/T of pulp produced.

MODEL PLANTS

A. Smelt Tank - 500 TPD

PM Emissions

500 TPD x 360 days/year x 0.5 lb/T = 90,000 lb/yr

NaOH Emissions

90,000 lb/yr x 0.5 x $\frac{1 \text{ kg}}{2.2 \text{ lb}}$ = 20,500 kg/yr

B. Smelt Tank - 1000 TPD

PM Emissions

1000 TPD x 360 days/year x 0.5 lb/T = 180,000 lb/yr

NaOH Emissions

180,000 lb/yr x 0.5 x $\frac{1 \text{ kg}}{2.2 \text{ lb}}$ = 40,900 kg/yr

C. Smelt Tank - 1500 TPD

PM Emissions

1500 TPD x 360 days/year x 0.5 lb/T = 270,000 lb/yr

NaOH Emissions

270,000 lb/yr x 0.5 x $\frac{1 \text{ kg}}{2.2 \text{ lb}}$ = 61,000 kg/yr

Actual Plants

A. James River - Butler, Alabama

PM Emission Estimates from NEDS based on Emission Tests

Tank 1-13 T/yr; Tank 2-14 T/yr; Tank 3-15 T/yr

NaOH Emission Estimates

Tank 1

13 T/yr x 0.5 x 2000 lb/T x 1kg/2.2 lb = 5,900 kg/yr

Tank 2

14 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 6,400 kg/yr

Tank 3

15 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 6,800 kg/yr

B. International Paper - Camden, Arkansas

PM Emission Estimates from NEDS Based on Emission Tests

Tank 1 - 31 T/yr; Tank 2 - 40 T/yr; Tank 3 - 32 T/yr

NaOH Emission Estimates

Tank 1

31 T/yr x 0.5 x 2000 lbT x 1 kg/2.2 lb = 14,000 kg/yr

Tank 2

40 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 18,000 kg/yr

Tank 3

32 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 14,500 kg/yr

C. Champion International - Pensacola, Florida

PM Emission Estimates from NEDS based on Emission Tests

Smelt Tank - General - 17 T/yr; Smelt Tank - General - 36 T/yr

NaOH Emission Estimates

Smelt Tank - General

17 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 7,700 kg/yr

Smelt Tank - General

36 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 16,400 kg/yr

D. Great Southern Paper - Cedar Springs, Georgia

PM Emission Estimates from NEDS Based on Emission Tests

Tank 1 - 55 T/yr; Tank 2 - 53T/yr; Tank 3 - 46 T/yr

NaOH Emission Estimates

Tank 1

55 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 25,000 kg/yr

Tank 2

53 T/yr x 0.5 x 2000 lb/T x 1kg/2.2 lb = 24,100 kg/yr

Tank 3

46 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb - 20,900 kg/yr

E. Union Camp - Savannah, Georgia

PM Emission Estimates from NEDS based on Emission Tests

Tank 12 - 19 T/yr; Tank 13 - 24 T/yr; Tank 14A/14B - 76 T/yr

NaOH Emission Estimates

Tank 12
19 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 8,600 kg/yr

Tank 13
24 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 10,900 kg/yr

Tank 14A/14B
76 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 34,500 kg/yr

F. Georgia-Pacific-Zachary, Louisiana

PM Emission Estimates from NEDS based on Emission Tests

Tank 1-32 T/yr; Tank 2A - 10 T/yr; Tank 2B - 10 T/yr

NaOH Emission Estimates

Tank 1

32 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 14,500 kg/yr

Tank 2A

10 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 4,500 kg/yr

Tank 2B

10 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 4,500 kg/yr

G. Crown Zellerbach - St. Francisville, Louisiana

PM Emission Estimates from NEDS based on Emission Tests

Tank 1 - 34 T/yr

NaOH Emission Estimate

34 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 15,000 kg/yr

H. Weyerhaeuser - New Bern, NC

PM Emissions from 2 Smelt Tanks

725 TPD x 360 D/yr x 0.5 lb/T x 1 T/2000 lb = 65 T/yr

NaOH Emission Estimate (2 Tanks)

65 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 29,500 kg/yr

I. Longview Fibre - Longview, Washington

PM Emissions from 4 Smelt Tanks

2,800 TPD x 360 D/yr x 0.5 lb/T x 1 T/2000 lb = 252 T/yr

NaOH Emission Estimates

Tank 11

$$\frac{\text{Est. PM Emission Tank 11 (From NEDS)}}{\text{Total PM Emissions - Smelt Tanks (From NEDS)}} \times 252\text{ T/yr} \times 0.5 \times 2000\text{ lb} \times 1\text{ kg/2.2 lb}$$

$\frac{24\text{ TPY}}{188\text{ TPY}}$ x 252 T/yr x 0.5 x 2000 lb/T x 1 kg/ 2.2 lb = 14,600 kg/yr

Tank 15

$\frac{64\text{ TPY}}{188\text{ TPY}}$ x 252 T/yr x 0.5 x 2000 lb/T x 1 kg/ 2.2 lb = 38,900 kg/yr

Tank 18

$\frac{19\text{ TPY}}{188\text{ TPY}}$ x 252 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 11,600 kg/yr

Tank 19

$\frac{81\text{ TPY}}{188\text{ TPY}}$ x 252 T/yr x 0.5 x 2000 lb/T x 1 kg/2.2 lb = 49,500 kg/yr

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4.0 BEER MANUFACTURING

4.1 INDUSTRY DESCRIPTION

Table 4-1 shows the 112 breweries located in the United States.

TABLE 4-1.

Breweries Located in the United States - 1986[1]

Company	Location
G. Heileman Brewing Co., Inc	Phoenix, AZ
Arkansas Brewing Co., Inc.	Little Rock, AR
Anchor Brewing Co.	San Francisco, CA
Anheuser-Busch, Inc.	Fairfield, CA
Anheuser-Busch, Inc.	Los Angeles, CA
Buffalo Bill's Brewery	Hayward, CA
Golden Pacific Brewing Co.	Emeryville, CA
Koryo Winery Co. (Sake Brewery)	Los Angeles, CA
Koryo Winery Co. (Sake Brewery)	Gardena, CA
Mendocino Brewing Co.	Hopland, CA
Miller Brewing Co.	Irwindale, CA
Old Los Angeles Brewery	Los Angeles, CA
Ozeki San Benito	Hollister, CA
Palo Alto Brewing Co.	Menlo Park, CA
Redwood Brewing Company	Petaluma, CA
Roaring Rock Brewery	Berkeley, CA
The Saxton Brewery	Chico, CA
Sierra Nevada Brewing Co.	Chico, CA
Stanislaus Brewing Co., Inc.	Modesto, CA
The Stroh Brewery Company	Los Angeles, CA
Takara Sake USA, Inc.	Berkeley, CA
Thousand Oaks Brewing Co.	Berkeley, CA
Truckee Brewing Company	Truckee, CA
U C at Davis (Exp-Brewery)	Davis, CA
Under the Oaks Brewery	Ojai, CA
Adolph Coors Co.	Golden, CO
Boulder Brewing Co.	Boulder, CO
Anheuser-Busch, Inc.	Jacksonville, FL
Anheuser-Busch, Inc.	Tampa, FL
The Florida Brewery, Inc.	Auburndale, FL
Pabst Brewing Co.	Tampa, FL
Miller Brewing Co.	Albany, GA
G. Heileman Brewing Co., Inc.	Perry, GA

Table 4-1. (cont.)

Company	Location
Honolulu Sake Brewery	Honolulu, HI
Snake River Brewing Co.	Caldwell, ID
G. Heileman Brewing Co., Inc.	Belleville, IL
Tae Hwa Brewing Co., Inc.	Waukegan, IL
Falstaff Brewing Corp.	Fort Wayne, IN
G. Heileman Brewing Co.	Evansville, IN
Dubuque Star Brewing Co.	Dubuque, IA
Millstream Brewing Co.	Amana, IA
Dixie Brewing Co., Inc.	New Orleans, LA
G. Heileman Brewing Co., Inc.	Baltimore, MD
G. Heileman Brewing Co., Inc.	Frankenmuth, MI
Geyer Bros. Brewing Co.	Frankenmuth, MI
Kalamazoo Brewing Co., Inc.	Kalamazoo, MI
The Real Ale Company, Inc.	Chelsea, MI
The Stroh Brewery Co.	Detroit, MI
Cold Spring Brewing Co.	Cold Spring, MN
G. Heileman Brewing Co., Inc.	St. Paul, MN
The Stroh Brewery Co.	St. Paul, MN
August Schell Brewing Co.	New Ulm, MN
Anheuser-Busch, Inc.	St. Louis, MO
Montana Beverages Ltd.	Helena, MT
Anheuser-Busch, Inc.	Merrimack, NH
Anheuser-Busch, Inc.	Newark, NJ
Champale, Inc.	Trenton, NJ
Eastern Brewing Corp.	Hammonton, NJ
Pabst Brewing Co.	Newark, NJ
Vernon Valley Brewery, Inc.	Vernon, NJ
Anheuser-Busch, Inc.	Baldwinsville, NY
Genessee Brewing Co., Inc.	Rochester, NY
Miller Brewing Co.	Fulton, NY
West End Brewing Co. of Utica, N.Y.	Utica, NY
William S. Newman Brewing Co. Inc.	Albany, NY

Table 4-1. (cont.)

Company	Location
Miller Brewing Co.	Eden, NC
The Stroh Brewery Co.	Winston-Salem, NC
Anheuser-Busch, Inc.	Columbus, OH
The Hudepohl Brewing Co.	Cincinnati, OH
Miller Brewing Co.	Trenton, OH
The Schoenling Brewing Co.	Cincinnati, OH
Columbia River Brewery	Portland, OR
G. Heileman Brewing Co., Inc.	Portland, OR
Hillside Brewery & Public House	Portland, OR
Portland Brewing Co.	Portland, OR
Widmer Brewing Company	Portland, OR
Jones Brewing Co.	Smithton, PA
Latrobe Brewing Co.	Latrobe, PA
The Lion, Inc.	Wilkes-Barre, PA
Pittsburgh Brewing Co.	Pittsburgh, PA
The Stroh Brewing Co.	Allentown, PA
C. Schmidt & Sons, Inc.	Philadelphia, PA
Straub Brewery, Inc.	St. Marys, PA
D.G. Yuengling & Sons, Inc.	Pottsville, PA
The Stroh Brewing Company	Memphis, TN
Anheuser-Busch, Inc.	Houston, TX
G. Heileman Brewing Co., Inc.	San Antonio, TX
Miller Brewing Co.	Fort Worth, TX
Pearl Brewing Co.	San Antonio, TX
Pearl Brewing Co.	Galveston, TX
Reinheitsgebot Brewing Co.	Plano, TX
Spoetzl Brewery, Inc.	Shiner, TX
The Stroh Brewing Co.	Longview, TX
Anheuser-Busch, Inc.	Williamsburg, VA
Chesapeake Bay Brewing Co.	Virginia Beach, VA
General Brewing Co.	Vancouver, WA
Hale's Ales, Ltd	Colville, WA
Hart Brewing, Inc.	Kalama, WA
G. Heileman Brewing Co., Inc.	Seattle, WA
Independent Ale Brewing, Inc.	Seattle, WA
Kemper Brewing Co.	Rollingbay, WA
Kufnerbrau	Monroe, WA
Pabst Brewing Co.	Olympia, WA
Yakima Brewing & Malting Co.	Yakima, WA
G. Heileman Brewing Co. Inc.	La Crosse, WI
Hibernia Brewing, Ltd.	Eau Claire, WI
Jos. Huber Brewing Co.	Monroe, WI

Table 4-1. (cont.)

Company	Location
Jacob Leinenkugel Brewing Co.	Chippewa Falls, WI
Miller Brewing Co.	Milwaukee, WI
Pabst Brewing Co.	Milwaukee, WI
Sprecher Brewing Co., Inc.	Milwaukee, WI
Stevens Point Beverage Co.	Stevens Point, WI

4.2 PROCESS DESCRIPTION

4.2.1 General

Between the ripe barley grain (a starchy raw material used in the form of malt) and the cool, satisfying glass of beer, many production steps are involved. A process flow diagram is given on Figure 4-1.

The four main steps in the production of beer are mashing, fermenting, storage or layering, and bottling. Barley malt is the principal ingredient for beer and is usually made by the malting industry. Essentially, malt is barley which has been soaked in water and allowed to germinate after which it is redryed and ground to a powder. Mashing is the process whereby, by help of enzymes, starch, sugar and proteins are converted to simpler water soluble fermentable compounds. Mashing occurs at temperatures of 140 - 160°F. The malt extract is dissolved in water and the resulting liquid is known as wort (unfermented beer). Hops are added to the wort in a brew kettle, where the wort is boiled one-and-a-half to three hours. The wort is strained to remove hops, and sludge is removed by a filter or centrifuge and is then cooled to 50°F. As the wort cools, air that is necessary to begin fermentation is absorbed by the wort. Yeast, usually obtained from an earlier brew, is mixed with the wort in line to the fermentation starter tanks. Fermentation, the conversion of simple sugars in the wort to ethanol and carbon dioxide, is completed in a closed fermenter. Cooling is required to maintain the proper fermentation temperature.

After fermentation is completed, beer is stored to age for several weeks at 32°F in large closed tanks. The beer is then recarbonated, pumped through a pulp filter, pasteurized at 140°F and packaged in bottles and cans. Draft beer is not pasteurized and some breweries such as Coors do not pasteurize bottled or canned beer.[2-4]

4.2.2 Specific Process of Interest

As shown in the next section, the only process sources estimated to emit sodium hydroxide at breweries are bottle washing systems. Returnable and nonreturnable bottles are first preheated and prerinsed. The bottles are then soaked in a caustic soda solution that varies from 0.5 - 5% at temperatures between 160 - 180°F. After soaking, the bottles in some machines are sprayed internally and externally with a caustic soda solution before going to the after-rinse. After-rinsing consists of spraying with hot water, lukewarm water and

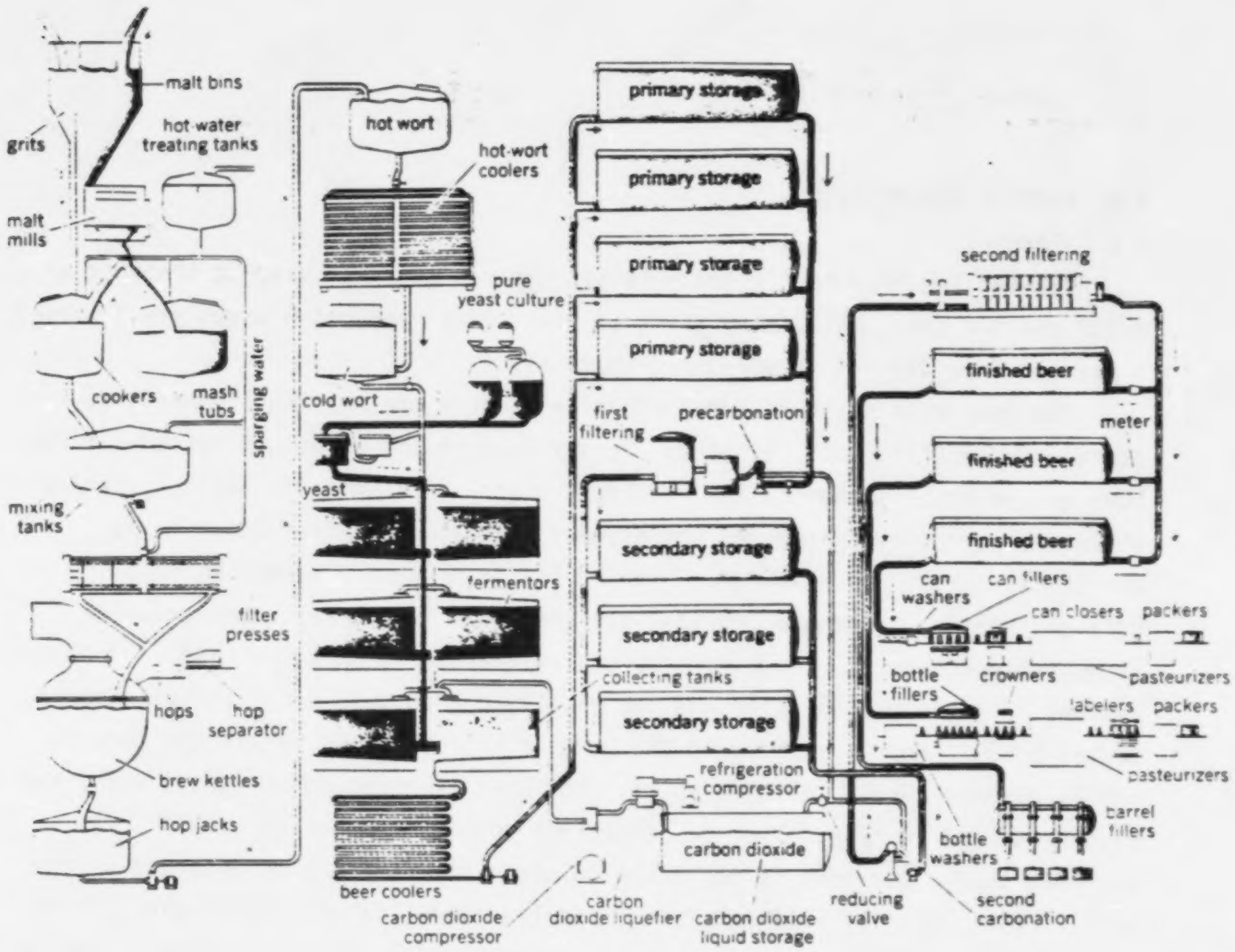
malt bins
grits
hot water treating tanks
malt mills
cookers
mash tubs
sparging water
mixing tanks
filter presses
hops
hop separator
brew kettles
hop jacks
hot wort
hot-wort coolers
pure yeast culture
cold wort
yeast
fermentors
collecting tanks
beer coolers
carbon dioxide compressor
carbon dioxide liquefier
primary storage
primary storage
primary storage
primary storage
first filtering
precarbonation
secondary storage
secondary storage
secondary storage
refrigeration compressor
carbon dioxide
carbon dioxide liquid storage
reducing valve
second filtering
finished beer
meter
finished beer
finished beer
can washers
can fillers
can closers
packers
bottle fillers
crowners
pasteurizers
labelers
packers
pasteurizers
barrel fillers
bottle washers
second carbonation

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Figure 4-1. Beer Manufacturing[2]

finally cold water. Bottle washing machines in the U.S. are usually fitted with 3 - 5 compartments for soaking with varying strengths of caustic soda and various temperatures. The strengths of the caustic soda solutions are set by law not to be below certain levels. After cleaning, the bottles are filled, closed with crown corks and then pasteurized.[4]

According to a representative of The Beer Institute, all breweries for the major brewing companies (Anheuser-Busch, Miller, etc.) will have a bottle washing process that uses sodium hydroxide. Also, all breweries in States such as New York and Pennsylvania, which have deposits on glass bottles would have bottle washing systems.[5] According to an Anheuser-Busch employee, all returnable bottles are washed with a sodium hydroxide solution to strip labels and for sterilization. Sodium hydroxide solutions are not used for washing new glass bottles.[6,7]

Detailed information was obtained on the two bottle washing systems used by Miller Brewing at their Fulton, New York brewery. The dimensions of each bottle washing system are 75 feet in length, 16 feet wide and a height of 15 feet and was manufactured by Barry Wehmiller Company, St. Louis, Missouri. Returnable bottles are placed on a rinsing conveyor which is initially treated by a caustic wash using a 5 percent sodium hydroxide solution. The tank has 11 compartments each with a capacity of 4,000 gallons. The tank is heated to an operating temperature of 120 - 175°F by steam indirect heating coils. The retention time of bottles in this tank is 36 minutes and approximately 1,200 bottles are washed per minute. At any one time, approximately 44,000 bottles are in each system. After the caustic wash tank, the bottles are rinsed in hot water tanks. The 5 percent caustic solution is obtained by tank trucks and is stored in a 10,000 gallon storage tank prior to bring pumped to various locations in the brewery.[7]

4.3 EMISSIONS

Sodium hydroxide emission estimates were developed by the State of New York for the Miller Brewing plant in Fulton, New York. These calculations are contained in the appendix to this chapter.

4.4 HEM INPUTS

HEM inputs for bottle washing at Miller Brewing, Fulton, New York are contained in Table 4-2.

TABLE 4-2.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM BEER MANUFACTURING

PLANT NAME	STATE	LAT. (deg, min, sec)	LONG. (deg, min, sec)	EMISS. TYPE	STACK HEIGHT (m)	CROSS-SECT. AREA (m^2)	STACK DIAMETER (m)	STACK VELOCITY (m/s)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	EMISSION SOURCE	CONTROL EQUIP.
Miller Brewing	NY	431804	762250	Stack	9.1	6.9	0.76	8.2	290	24,000	Bottle Washing System	None
				Stack	9.1	5.6	0.61	8.2	290	24,000	Bottle Washing System	None

APPENDIX - CHAPTER 4 - THE BEER INDUSTRY

Miller Brewing - Fulton, NY

- Bottle Washing System

Engineering estimate from Miller Brewing

- 0.008 lb moisture/lb of air
- 23,085 lb of air/hour

$$0.008\ \frac{\text{lb moisture}}{\text{lb of air}} \times 23{,}085\ \frac{\text{lb of air}}{\text{hour}} = 185\ \frac{\text{lb moisture}}{\text{hour}}$$

Solution for system in 5% sodium hydroxide
- Assume moisture is also 5% sodium hydroxide

$$185\ \frac{\text{lb moisture}}{\text{hour}} \times 0.05 = 9\ \frac{\text{lb NaOH}}{\text{hour}}$$

Hours of operation - 21.5 hours/day; 273 days/year
so yearly emissions of sodium hydroxide are:

$$9\ \frac{\text{lb NaOH}}{\text{hour}} \times 21.5\ \frac{\text{hours}}{\text{day}} \times 273\ \text{days/yr} = 52{,}800\ \frac{\text{lb NaOH}}{\text{year}}$$

$$52{,}800\ \frac{\text{lb}}{\text{yr}} \times \frac{1\ \text{kg}}{2.2\ \text{lb}} = 24{,}000\ \frac{\text{kg}}{\text{yr}}$$

4.5 REFERENCES

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5.0 AUTOMOTIVE CARBURETOR MANUFACTURING INDUSTRY

5.1 INDUSTRY DESCRIPTION

Table 5-1 shows the primary automotive carburetor manufacturing plants in the United States. According to a printout from the Automotive Parts Rebuilders Association, there are approximately 140 fuel system rebuilders most of which rebuild carburetors.[1]

5.2 PROCESS DESCRIPTION

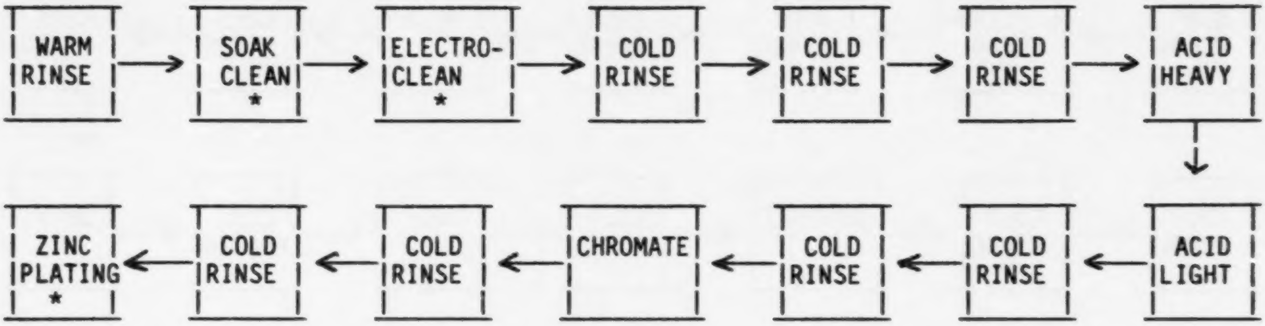
Information was obtained from four primary carburetor manufacturing plants and two rebuilt carburetor manufacturing plants. Sodium hydroxide solutions are used very infrequently in rebuilt carburetor manufacturing and then only for smaller installations. Three of the five primary carburetor manufacturing plants use these solutions. One of the other primary carburetor manufacturing plants (Ford - Ypsilanti, Michigan) uses potassium hydroxide for plating and metal cleaning.

Process information was obtained from Holley Automotive, Bowling Green, Kentucky. Figure 5-1 shows the process flow for the five lines at this plant that use sodium hydroxide solutions. Those processes that use caustic soda are identified with astericks. These lines are manual or automotive and are operated 16 hours/day; 5 days/week. Maximum operating rates for each line are: DMP Automatic - 500 lb/hr; Udylite - 900 lb/hr; DMP Manual - 400 lb/hr and Adjamatic and Deoxidize lines - 650 lb/hr. The DMP Auto and Udylite lines are zinc plating lines. DMP Manual is a black oxide and phosphate coating process. The Adjamatic and Deoxidize lines put a chromate finish on carburetor pieces. Each carburetor piece goes through only one of these lines. There are approximately 20 - 100 metal pieces per batch. The concentrations of the caustic soda solutions used vary from 5 - 10 percent. The operating temperatures for those processes that use these solutions vary from 135 - 140°F. Tanks are directly heated by electrical heat elements. Metal pieces stay in the bath for a maximum of 3 minutes, except the zinc electroplating tanks where parts can stay up to 20 minutes. Tanks are dumped weekly to a pretreatment system. The waste goes to one of three electrochemical treatment cells and then to two rectangular clarifiers in series. The liquid discharge from the

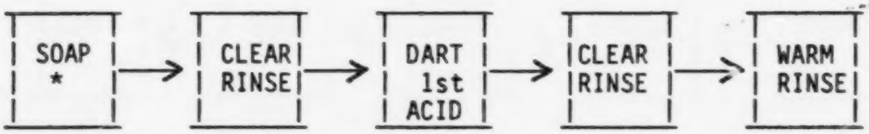
TABLE 5-1. U.S. Primary Automotive Carburetor Manufacturing Plants

COMPANY	LOCATION
Holley Automotive	Bowling Green, Kentucky
Ford Motor Company	Ypsilanti, Michigan
Carter Carburetor	St. Louis, Missouri
Rochester Products, Division of General Motors	Rochester, New York
Weber Carburetor	Sanford, North Carolina

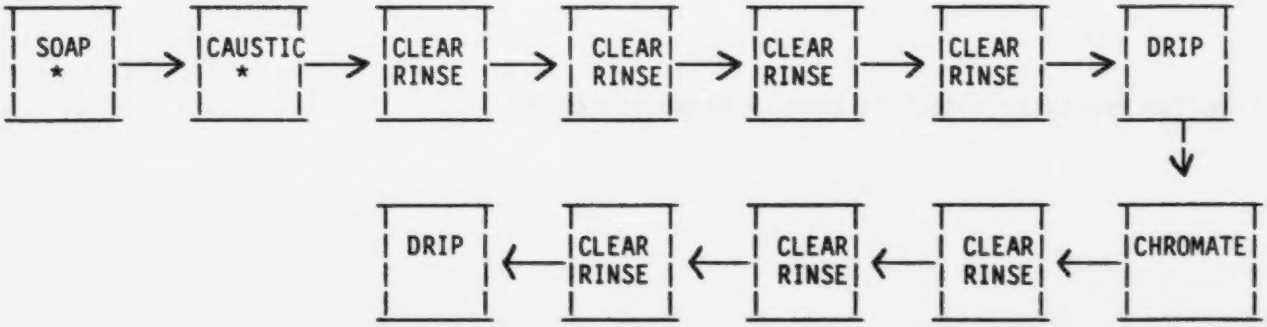
DMP AUTOMATIC PLATING


WARM RINSE
SOAK CLEAN *
ELECTRO-CLEAN *
COLD RINSE
COLD RINSE
COLD RINSE
ACID HEAVY
ACID LIGHT
COLD RINSE
COLD RINSE
CHROMATE
COLD RINSE
COLD RINSE
ZINC PLATING *

DEOXIDIZE LINE


SOAP *
CLEAR RINSE
DART 1st ACID
CLEAR RINSE
WARM RINSE

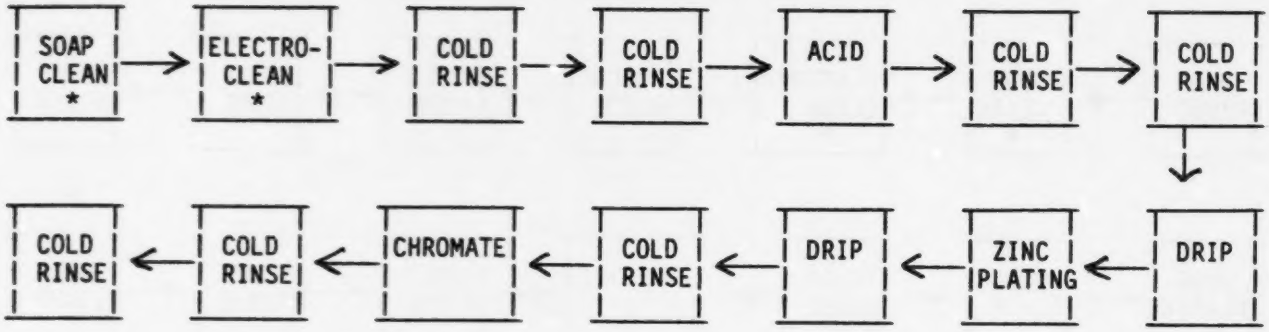
ADJAMATIC


SOAP *
CAUSTIC *
CLEAR RINSE
CLEAR RINSE
CLEAR RINSE
CLEAR RINSE
DRIP
CHROMATE
CLEAR RINSE
CLEAR RINSE
CLEAR RINSE
DRIP

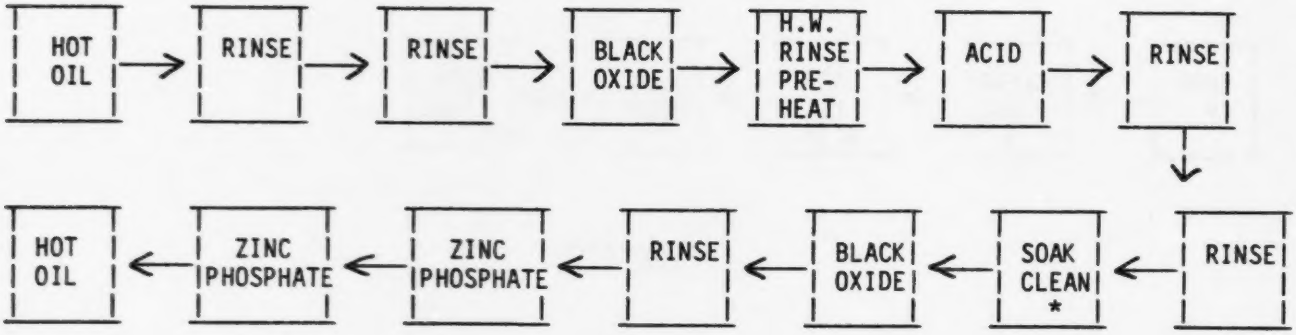
* Sodium hydroxide solutions used in these processes

Figure 5-1. Process Lines - Holley Automotive - Bowling Green, Kentucky[2]

UDYLITE PLATING


SOAP CLEAN *
ELECTRO-CLEAN *
COLD RINSE
COLD RINSE
ACID
COLD RINSE
COLD RINSE
DRIP
ZINC PLATING
DRIP
COLD RINSE
CHROMATE
COLD RINSE
COLD RINSE

DMP MANUAL PLATING


HOT OIL
RINSE
RINSE
BLACK OXIDE
H.W. RINSE PRE-HEAT
ACID
RINSE
RINSE
SOAK CLEAN *
BLACK OXIDE
RINSE
ZINC PHOSPHATE
ZINC PHOSPHATE
HOT OIL

* Sodium hydroxide solutions used in these processes

Figure 5-1. Process Lines - Holley Automotive - Bowling Green, Kentucky[2] (continued)

final clarifier is discharged to the city sewer. The sludge collected by the clarifiers passes to a filter press and then a sludge dryer. The dryer produces a fine powder that is hauled to a hazardous waste landfill. All tanks have stainless steel construction with a capacity for each tank of 160 gallons. Tank dimensions are 36 inches in width, 40 inches long, and 30 inches high.[3]

Details on the purpose of these tanks and other information is contained in Chapter 6 - Electroplating.

5.3 EMISSIONS

5.3.1 Uncontrolled Emissions.

Uncontrolled emission estimates for all processes at Rochester Products are shown on Table 5-3 as none of these processes have emission control equipment. The method that was used to determine some of these estimates is contained in the appendix to this chapter. All estimates were developed by plant personnel. Uncontrolled emissions for the various plating lines at Holley Automotive are contained in a printout from the State of Kentucky and are given in Table 5-2.

5.3.2. Emission Control Equipment

Only one automotive carburetor manufacturing plant, Holley Automotive, is known to have emission control equipment. Each tank that uses caustic soda including zinc electroplating bath tanks has a push/pull ventilation system that is exhausted to a scrubber. There are four packed tower scrubbers that use water as the scrubbing medium and the packing media is composed of polypropylene. The operating pressure drop is 6 inches of pressure water gauge and discharged water goes to a pretreatment system. The scrubbers are manufactured by KCH of Forest City, North Carolina. Emissions from tanks that do not use caustic soda are ducted to other scrubbers.[3]

5.4 HEM INPUTS

HEM inputs for this industry are given in Table 5-3. These inputs were obtained from printouts obtained from the States of New York and Kentucky. These estimates were discussed with plant personnel and changes were made where appropriate. The methodology of determining some of these estimates for Rochester Products is contained in the appendix to this chapter.

TABLE 5-2. UNCONTROLLED EMISSIONS - HOLLEY AUTOMOTIVE - BOWLING GREEN, KENTUCKY[4]

Process	Pollutant	Emissions (TPY)
Manual & Auto DMP Plating	TSP	0.027
	H_3PO_4	0.003
	Nitric Acid	0.015
	HCl	0.056
	Sodium Hydroxide	0.104
Automatic DMP Plating	HCl	0.016
	Sodium Hydroxide	0.180
Adjamatic & Deoxidize	H_3PO_4	0.016
	Sodium Hydroxide	0.004
Udylite Plating	HCl	0.120
	Sodium Hydroxide	0.220

TABLE 5-3.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM CARBURETOR MANUFACTURING

PLANT NAME	STATE	LAT. LONG. (DEG, MIN, SEC)	EMISSION TYPE	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Rochester Products	NY	431049 773923	Stack 10	12	6.1	0.51	11.2	297	2990	Manual Plating Cleaning Tank	None
			Stack 11	12	7.3	0.61	21.3	297	450	Zinc Plating Tank	None
			Stack 14	12	6.1	0.51	10.9	297	1700	Caustic Cleaning Tanks	None
			Stack 24	11	3.3	0.30	3.0	311	0.5	Automatic Tote Pan Washer	None
			Stack 82	11	4.5	0.41	9.1	297	550	Caustic Solution Tanks	None
			Stack 160	12	7.3	0.61	11.6	297	16100	3 Ionic Zinc Plating Tanks	None
			Stack 162	12	7.3	0.61	10.7	297	710	Sodium Zincate Plating Bath	None
			Stack 163	12	7.9	0.66	12.2	297	1040	Ionic Zinc Plating Tank	None
			Stack 164	12	7.9	0.66	12.2	297	1040	Ionic Zinc Plating Tank	None
			Stack 165	12	7.3	0.61	10.7	297	710	Sodium Zincate Plating Bath	None
			Stack 218	9	5.5	0.61	10.4	319	3450	Caustic Cleaning	None
			Stack 282	11	4.5	0.41	6.7	333	0.9	Drum-Type Washer	None
			Stack 286	10	6.1	0.61	4.0	297	990	Caustic Cleaning Tank	None
			Stack 296	10	9.5	0.95	12.2	303	820	Carden Plater	None
Holley Carburetor	KY	365837 855420	Stack 13	9	10.0	1.1	20.0	299	0.9	Manual & Auto. DMP Plating *	Packed Tower Scrubber
			Stack 14	9	10.0	1.1	20.0	299	1.8	Manual & Auto. DMP Plating**	Packed Tower Scrubber
			Stack 18	9	7.2	0.8	20.0	299	0.0	Adjamatic & Deoxidize	Packed Tower Scrubber
			Stack 19	9	8.1	0.9	17.0	299	1.8	Udylite Plating	Packed Tower Scrubber

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* Manual DMP - Acid, 2 zinc phosphate tanks; Automatic DMP - Acid (light and heavy), chromate.

**Manual DMP - Hot oil, soak clean, black oxide; Automatic DMP - soak clean, electroclean, zinc plating.

APPENDIX - CHAPTER 5

Rochester Products - Rochester, NY

Sodium hydroxide emission estimates were developed by the company and submitted to the State agency. Calculations for some of these processes were sent by the State of New York and were discussed with plant personnel. These processes are discussed below.

1. Emission Point -0010 (Four Manual Plating Cleaning Tanks)

From Industrial Ventilation; 18th Edition, p. 4-19

$Q = 2.8\ LVX$ (Slot on table or bench)

Q = Required exhaust volume; cfm
L = Length of hood, slot, table; feet
V = Capture velocity at distance X; fpm
X = Distance from hood face to furthest point of source; feet

$$V = \frac{Q}{2.8LX} = \frac{1200\ \text{cfm/tank}}{2.8\ (1.5\ \text{ft})(8\text{ft})} \quad \text{(four tanks)}$$
$$= 35.8\ \text{ft/min}$$

From Buffalo Forge Fan Engineering, p. 95

$$W = \left(\frac{95 + 0.425V}{r}\right)(e_w - e_a)$$

W = amount of water evaporated, $\text{lb/ft}^2\text{/hr}$
V = longitudinal velocity of air, ft/min
r = latent heat of vaporization
e_w = vapor pressure that corresponds to water temp. of process, (in Hg)
e_a = vapor pressure of moisture in air (in Hg)

$$W = \left(\frac{95 + (0.425)(35.8)}{1014}\right)(5.881 - 0.436)$$
$$= 0.59\ \text{lbs/hr/ft}^2\text{/tank}$$

Sodium Hydroxide Emissions for all four tanks (5.7% NaOH in tank)

a. Hourly

$(0.59\ \text{lbs/hr/ft}^2\text{/tank})\ (4\ \text{tanks})\ (12\ \text{ft}^2\text{/tank})(.057) = 1.63\ \text{lbs/hr}$

b. Yearly

$(1.63\ \text{lbs/hr})\ (16\ \text{hrs/day})\ (252\ \text{days/yr}) = 6570\ \text{lb/yr}$

$6570\ \text{lb/yr} \times \left(\frac{1\text{kg}}{2.2\text{lb}}\right) = 2990\ \text{kg/yr}$

2. Emission Point - 0014 (2 Caustic Cleaning Tanks)

Q = 3.7 LVX (Freely Suspended Slot)

Q = Required exhaust volume; cfm
L = Length of hood, slot, table; feet
V = Capture velocity at distance X; fpm
X = Distance from hood face to farthest point of source; feet

$$V = \frac{Q}{3.7(LX)} = \frac{2300 \text{ cfm/tank}}{3.7\ (8\text{ft})(2\text{ft})} = 38.8 \text{ ft/min}$$

$$W = \left(\frac{95 + 0.425\ V}{r} \right) (e_w - e_a)$$

$$= \left(\frac{95 + 0.425\ (38.8)}{1014} \right) (5.881 - 0.436)$$

$$= 0.60 \text{ lbs/hr/ft}^2$$

Sodium Hydroxide Emissions from 2 tanks (4.3% NaOH in tank)

a. Hourly

$(0.60 \text{ lbs/hr/ft}^2)\ (36\text{ft}^2)\ (0.043) = 0.93 \text{ lbs/hr}$

b. Yearly

(0.93 lbs/hr) (16 hrs/day) (252 days/yr) = 3750 lbs/yr

$3{,}750 \text{ lbs/yr} \times \left(\frac{1\text{kg}}{2.2\text{lb}} \right) = 1700 \text{ kg/yr}$

3. Emission Point -0011 (1 Zinc Plating Tank)

Q = 960 cfm/section (4 sections in tank)

Q = 3.7 LVX

$$V = \frac{Q}{3.7\ (L)(X)} = \frac{960}{3.7\ (4)(1.75)}$$

$$= 37 \text{ ft/min}$$

$$W = \left(\frac{95 + 0.425}{R}\ V \right) (e_w - e_a)$$

$$= \left(\frac{95 + 0.425\ (37)}{1051.4} \right) (0.875 - 0.436)$$

$$= 0.046 \text{ lbs/hr/ft}^2 \text{ of tank}$$

The tank is 4 ft deep x 16 ft long

Total Hourly Emissions

$(0.046 \text{ lbs/hr/ft}^2)\ (64 \text{ ft}^2) = 2.94 \text{ lbs/hr}$

NaOH Yearly Emissions (Tank is 8.3% NaOH)

(2.94 lb/hr) (16 hr/day) (252 day/yr) (0.083) = 980 lb/yr

$980 \text{ lb/hr } \left(\frac{1\text{kg}}{2.2\text{lb}}\right) = 450 \text{ kg/yr}$

5.5 REFERENCES

1. Letter and attachment from Kroell, K., Automobile Parts Rebuilders Association, to Neuffer, W.J., EPA. May 14, 1987. List of fuel systems rebuilders.

2. Letter and attachment from Wells, T., Holley Automotive Division, to Neuffer, W.J., EPA. June 8, 1987. Process Flow Diagram.

3. Telecon. Wells, Ted, Holley Automotive Division with Neuffer, W.J., EPA. May 14, June 16, and June 17, 1987. Process and emission control information on Bowling Green, Kentucky plant.

4. Letter and attachment from Parker, D.M., Division for Air Quality, Commonwealth of Kentucky, to Neuffer, W.J., EPA. February 2, 1987. Printout from the Kentucky Emissions Inventory System.

6.0 METAL FINISHING

6.1 INDUSTRY DESCRIPTION

According to the 1982 Census of Manufacturers, SIC 3471 (Electroplating, plating, polishing, anodozing, coloring, and finishing of metals and formed products) has 3,367 companies and 3,450 establishments. Eight hundred and ninety eight of these establishments employ more than 20 employees.[1] One hundred and sixty four plants have greater than 100 employees. A list of plants in this SIC code with greater than 500 employees is shown on Table 6-1.

6.2 PROCESS DESCRIPTION

6.2.1 General

Electroplating is the main plating technique used and is the production of a thin metal surface coating on another metal by electrodeposition. Other plating methods are discussed later. This surface coating is applied to provide corrosion protection, wear or erosion resistance, anti-frictional characteristics or for decorative purposes.[3] In electroplating, metal ions in either acid, alkaline or neutral solutions are reduced on cathodic surfaces which are the pieces being plated. The most common methods of plating are in barrels, on racks or continuously from a spout or coil.[3] The main processes involved in metal finishing are shown on Figure 6-1.

Before a metal can be electroplated, the metal surface must be prepared to ensure the desired bond. Cleaning is a term used to describe the preplating treatments necessary to prepare the surface to accept a metal deposit. Cleaning removes dirt, oils, grease and other foreign material from the metal surface. Cleaning may range from a single dip in a mild detergent to a combination of several treatments. A typical cleaning cycle includes the following steps: (1) Pickling to remove gross scale (This is often done prior to the plating department); (2) mechanical preparations such as polishing and grinding to smooth metal surfaces; (3) cleaning (usually consisting of many operations) to remove oils, grease, shop dirt, polishing and buffing compounds; (4) rinsing; (5) acid dipping to remove oxide films; and (6) rinsing.[4]

TABLE 6-1. METAL FINISHING - U.S. PLANTS WITH GREATER THAN 500 EMPLOYEES[2]

Plant Name	Location
American Industrial Chromium	Pittsburgh, Pennsylvania
Bristol Corporation	Newport Beach, California
Crown City Plating Company	El Monte, California
Dynacraft Incorporated	Santa Clara, California
Minnesota Mining & Manufacturing Company	Nevada, Missouri
Providence Metallizing Company	Pawtucket, Rhode Island
Stolle Corporation	Sidney, Ohio
Summit Corporation of America	Thomaston, Connecticut
Superior Industries International	Van Nuys, California
Worldmark Corporation	N. Palm Beach, Florida

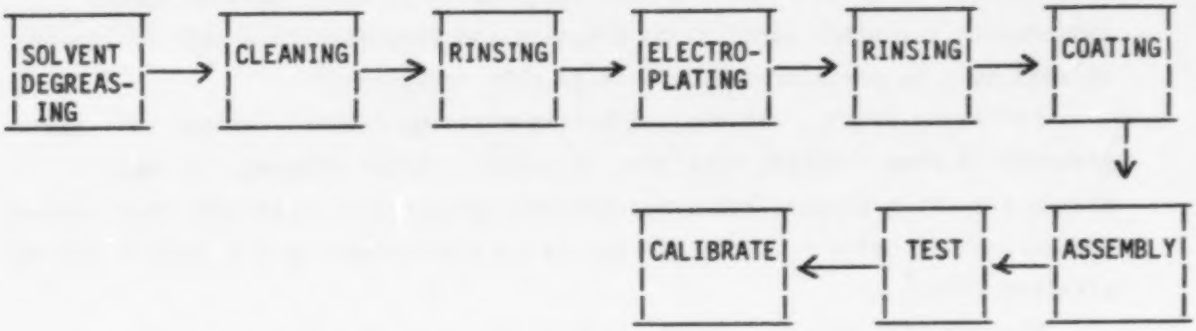
SOLVENT DEGREASING
CLEANING
RINSING
ELECTRO-PLATING
RINSING
COATING
ASSEMBLY
TEST
CALIBRATE

Figure 6-1. Metal Finishing[3]

Organic solvents are used to dissolve most oils and greases including those used to bind buffing and polishing compounds. This may be done by dipping, but is usually done by vapor degreasing in which solvent vapors condense on the metal parts to be cleansed and flow back to a pool of liquid solvent such as perchloroethylene or trichloroethylene.[4]

Following organic cleaning, alkaline cleaning removes surface soil and prevents it from settling back into the metal. After rinsing, the metal pieces are often dipped into a hydrochloric or sulfuric acid bath that removes the tarnish or oxide films formed during alkaline cleaning and neutralizes the alkaline film.[4]

Plating then occurs. There are four types of plating that can be used: electroplating, electroless plating, immersion plating and anodizing. Electroplating is the production of a thin surface coating of one metal upon another by eletrodeposition. Electroless plating is a chemical reduction process which depends upon the catalytic reduction of a metallic ion in a aqueous solution and subsequent deposition of metal without using electricity. Immersion plating is a chemical plating process in which a thin metal deposit is obtained by chemical displacement of the base metal. Anodizing is an electrolytic oxidation process which converts the metal surface to an insoluble oxide.[3]

After rinsing, postplating treatments include chromate conversion coatings for zinc and cadmium and phosphate treatments for zinc. These processes improve the corrosion protection for the deposit and inhibit the formation of bulky corrosion products.[4] Phosphate coating provides a good base for paint as well as impacting corrosive resistance.

Metal coloring involves chemical methods of coloring in which the metal surface such as copper, steel, zinc and cadmium is converted to an oxide for a decorative finish.

Next, the metal pieces that have been plated are fitted together into a complete machine, unit of a machine, or structure. This product is then tested by applying thermal, electrical or mechanical energy to determine the suitability of the product. Finally, the product is calibrated by applying thermal, electrical or mechanical energy to establish reference points.[3]

6.2.2 Specific Processes of Interest

This section describes the various metal finishing processes that use sodium hydroxide (caustic soda) solutions. As mentioned earlier, alkaline cleaning is used to remove oily dirt or solid soils from metal workpieces. Alkaline cleaners are used quite often as secondary cleaners after detergent soaking. These cleaners are aqueous solutions of sodium compounds such as carbonate, silicate, phosphate or hydroxide and usually contain a surfactant.[4] Alkaline cleaning may be performed by one or combination of three techniques: soak, spray or electroclean. This type of cleaning is operated at temperatures between 120 - 200°F at sodium compound concentrations between 0.5 - 2 lbs/gallon.[5]

Soak cleaning is used for metals with easily removed soils. The metal part is immersed in a plain steel tank with some possible mild agitation.[6] Conventional soak cleaning has alkaline cleaner concentrations of 8-12 oz/gal, operating temperatures of 150-190°F and retention times of 1-15 minutes.[6] Low temperature soak cleaners have concentrations of 2-4 oz/gal, operating temperatures of 70-90°F and similar retention times. Soak cleaning is less efficient than spray or electrocleaning.

In spray cleaning, the impact force of the spray makes cleaning more effective but limits the use of surfactants that are foamy. Operating parameters vary as alkaline cleaners concentrations vary from 0.5-4 oz/gal, operating temperatures from 120-160°F and retention times from 1-3 minutes.[6]

Electrolytic cleaning produces the cleanest surface available because of the strong agitation of the solution by gas evolution and oxidation - reduction reactions that occur during electrolysis. It is mostly used prior to electroplating and generally follows other cleaning procedures. Common operating conditions are alkaline cleaner concentrations varying from 8-14 oz/gal, operating temperatures from 130-200°F, retention times from 0.5-2 min. and current densities from 20-150A/ft^2.[6] A dilute mineral oil dip usually follows the final electrocleaner to neutralize the alkaline film on the metal surface.[5]

Electroplating consists essentially of connecting the parts to be plated to the negative terminal (cathode) of a direct current and another metal piece to the positive terminal (anode) and immersing both in a solution containing ions of the metal to be deposited. Metals dissolve at the anode and are plated at the cathode.[7]

A typical plating tank is shown on Figure 6-2. Plating tanks are either constructed of polyvinyl chloride or steel which requires no lining for alkaline solutions. For neutral or acid solutions, steel tanks are lined with rubber or plastic. Parts to be plated are hung in the tank on wires or on racks. DC power is conveyed to plating tanks by bus bars. The anodes are hung into the tanks from the positive bus bar usually along two sides, and work to be plated is placed down the center. Most large plating operations are conducted on conveyor tanks. Small parts to be plated are contained in wire baskets or usually barrels, with perforated plastic sides. Barrels rotate on a horizontal axis in the tank.[4, 7]

It is usually helpful to agitate the solution such as by air agitation or by stirring or pumping the plating solution. In addition to the metal ions contained in this solution, relatively large quantities of various substances used to increase the electrical conductivity and for buffering are added.[7] Temperature control is nearly always required because the characteristics of plating solutions, and of the deposit depend to a large extent on the operating temperature.[4]

In addition to the basic equipment (power source, plating, cleaning and rinsing tank, and bus bars), most plating installations require one or more of the following: filters - for either continuous or intermittent solution purification; drying facilities, racking stations where work may be hung and unracked after plating, and stripping tanks for stripping faulty deposits or plating racks.

Sodium hydroxide solutions are used in the following electroplating baths: cadmium cyanide, copper cyanide, stannate tin, zinc cyanide and brass plating.[3] The cadmium cyanide bath has the following compositions (oz/gal) if barrels are used: NaCN - 11-19.5, Cd-1.5-2.6, NaOH-2-3, Na_2CO_3-2.0. If racks are used to hold the metal parts, the following concentrations are used NaCN-8-16, Cd-2-4, NaOH-1.5-3 and Na_2CO_3-2.0. Operating temperatures vary from 80-100°F.[8] For copper plating, caustic soda is required for good bath conductivity, and improved brightness. Typical bath composition (oz/gal) for high efficiency copper cyanide baths is CuCN-10, NaCN-13.6, and NaOH-4.[9] A tin stannate plating system uses either sodium or potassium salts. Potassium salts are favored for generally superior operating conditions. Operating bath temperatures range from 150-190°F.[4]

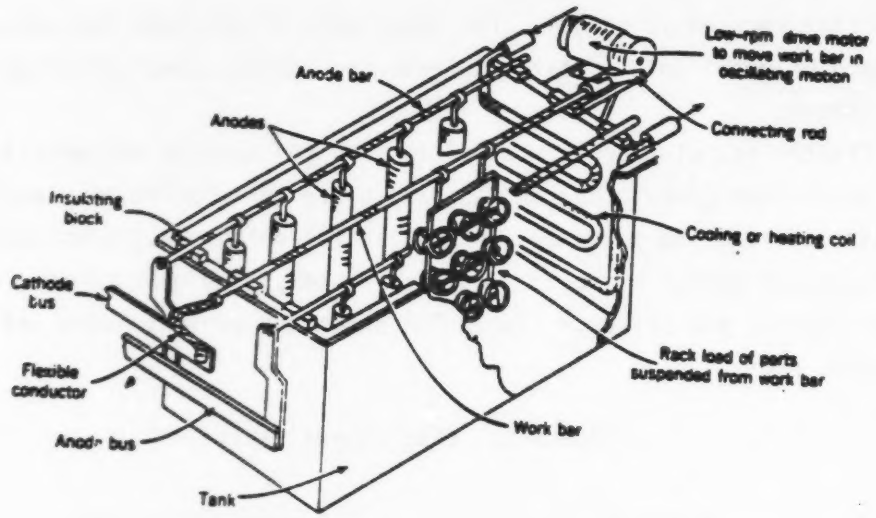
Low-rpm drive motor to move work bar in oscillating motion
Anode bar
Anodes
Connecting rod
Insulating block
Cooling or heating coil
Cathode bus
Flexible conductor
Rack load of parts suspended from work bar
Work bar
Anode bus
Tank

Figure 6-2. Cut-away view of plating tank.[4]

Zinc plating baths are composed (oz/gal) of Zn $(CN)_2$ -4-8; NaCN-2.7-5.4, and NaOH-8-15. Operating temperatures range from 85-130°F.[8] Sodium hydroxide is also used for white brass plating. White brass was substituted for nickel when nickel was in short supply. It is still used for toys and tubular furniture as well as by one major automobile manufacturer. Operating conditions are NaOH-30-37.5g/liter and operating temperatures of 70-84°F.[7]

Electroless plating is a continuous chemical reduction process in which metal ions are reduced by chemical agents in a plating solution and deposited on the material to be plated. The process is similar to electroplating except no outside current is needed. The components of the bath include an aqueous solution of metal ions, catalysts, reducing agents, complexing agents and bath stabilizers.

Electroless plating is most often used for coating non-metallic parts such as printed circuit boards, as base plate for plating on plastics and as a protective coating on metal parts. The following electroless plating processes use sodium hydroxide: copper, nickel, gold over copper, nickel, kovar; arsenic and silver.[3] Table 6-2 shows the various baths and the compounds used.

TABLE 6-2. Electroless Plating[3,5]

Metal	Compound	Concentration (g/l)	Temp (°F)
Copper	Copper sulfate ° $5H_2O$	5-13.8	68-86
	Sodium potassium tartrate ° $4H_2O$	25-69.2	
	Sodium hydroxide	7-20	
	Formaldehyde (37%)	10-38 ml/l	
Nickel	Nickel chloride	31	200-205
	Sodium hydroxide	42	
	Ethylenediamine, 98%	52	
	Sodium borohydride	1.2	
	Thallium nitrate	0.022	
Silver	Sodium silver cyanide	1.83	55
	Sodium cyanide	1.0	
	Sodium hydroxide	0.75	
	Dimethylamine borane	2.0	

Immersion plating is a chemical plating process in which a thin metal deposit is obtained by chemical displacement of the base metal. A metal will displace from solution any other metal that is below it in the electromotive series of elements.[3] Caustic soda solutions are used for the following plating operations: brass on aluminum, cadmium on steel, lead on copper and tin on copper alloys. The concentration of caustic soda in the plating bath and operating temperatures are shown below.[3,5]

Process	Concentration (oz/gal)	Temperature (°F)
Brass on aluminum	42	110-115
Cadmium on steel	70 - 75	255
Lead on copper	14	Room Temp.
Tin on copper	3	Room - 150

Etching and chemical milling are processes that produce a surface that conceals imperfections, produces a decorative effect or roughens the surface. The difference between etching and milling is that the rates and depths of metal removal are usually much greater in milling. Processes that use caustic soda are aluminum and tungsten etching and molybdenum alloys milling.[3]

Aluminum etching uses an aqueous caustic soda bath at concentrations of 3-8 oz/gal. Operating temperatures are 140-180°F for a period of 0.5-10 minutes. Typically, a concentration of 5 oz/gal at 160°F for 5 minutes removes 0.001 inch (1 mil) of metal. This amount of metal removed is sufficient to remove surface imperfections and provides a satin or matte finish.[6]

Another use of caustic soda in the metal finishing industry is for the coloring of metals. One of the most common is the alkaline blackening treatment of steel. Various formulations are used for the treating baths from a number of suppliers. One reference states that the bath solution is a 40 percent aqueous solution of sodium hydroxide to which 5 percent each of sodium and potassium nitrates are added.[11] Other formulations are caustic soda - 8 lbs/gal; sodium nitrate 1.5 oz/gal; sodium dichromate - 1.5 oz/gal; or caustic soda - 5 lb/gal, potassium nitrite - 1.9 oz/gal, potassium nitrate 1.25 oz/gal.[5] Processing bath temperatures range from 275 - 320°F and immersion times vary from

5-30 minutes. The coatings formed on steel by these treatments are mostly magnetic oxides and are in the order of 0.00003 - 0.00007 inches thick. Coating color and characteristics are a function of which type of alloy is treated, surface characteristic, bath concentration and temperature, and retention time. These coatings are porous and not particularly corrosion resistant.[6] The colored metal articles are usually finished by immersion in hot greases, oils or waxes followed by wiping and polishing.[11]

Other metal colorings where caustic soda is used are flemish on brass and blueing steel. The flemish finish on brass is produced by arsenic plating having the following bath composition - white arsenic - 16 oz/gal, caustic soda - 16 oz/gal and sodium cyanide - 1/2 oz/gal. The bath is operated at 70-110°F with a current density of 3-20 amp/ft^2. One of five bath types that produces a blue color on steel uses caustic soda. The bath has concentrations of caustic soda - 5 oz/gal, white arsenic - 5 oz/gal and sodium cyanide - 1 oz/gal. The current density is 2 amp/ft^2 and retention time varies from 2-4 minutes.[5]

6.3 EMISSIONS

As shown on Table 6-3, sodium hydroxide emission estimates were obtained for 25 plants from the States of Kentucky, New Jersey and New York for SIC 3471. As shown on this Table, only 3 of the 58 sources have emission control equipment and these three have scrubbers. Sodium hydroxide emission estimates for entire plants in this SIC code vary from 34 - 10,200 Kg/yr. Individual process units vary from 1 - 8,900 kg/yr.

Emission test data was obtained from a plating shop at the Norfolk Naval Shipyard. One ventilation line exhausted an electrocleaning tank (using caustic soda), as well as nitric acid, and hydrogen chloride tanks. Emissions are controlled by a spray scrubber that according to the emission test report was not operating properly. Test results show sodium hydroxide emissions of 0.17 lb/hr and hydrogen chloride emissions of 2.5 lb/hr.

6.4 HEM INPUTS

The inputs used to access health risks from exposure to sodium hydroxide emissions from 25 plants in SIC 3471 are given in Table 6-3. These data represent all plants in this SIC code that were contained in computer printouts of sodium hydroxide emissions from the States of Kentucky, New Jersey, New York, and Texas.

TABLE 6-3.

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM METAL FINISHING

PLANT NAME	STATE	LAT. (DEG, MIN, SEC)	LONG. (DEG, MIN, SEC)	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Central Kentucky	KY	380104	842653	Fug					311	37	2 Cleaning Tanks	None
				Stack	1	0.5	0.5	1	311	41	Black Oxide Tank	Wet Scrubber
				Fug					311	14	Cleaning Tank	None
				Stack	3	0.9	0.3	1	311	1	3 Cleaning Tanks	Wet Scrubber
				Stack	3	0.9	0.3	1	311	53	Cleaning Tank	None
Mid-South Electric	KY	371857	834714	Fug					298	130	3 Electroplating Tanks	None
Midway Fabricating	KY	363032	885333	Fug					298	16	Alkaline Soak Clean	None
				Fug					298	34	2 Electrocleaners	None
				Fug					298	35	Alkaline Soak Clean	None
				Fug					298	16	Electrocleaner	None
				Fug					298	36	Electrocleaner	None
				Fug					298	110	2 Electrocleaners	None
				Fug					298	160	Electrocleaner	None
N.I. Industries	KY	375248	843420	Stack	18	22	1.2	12	298	33	Plastic Product Fabrication	Wet Scrubber
				Stack	18	22	1.2	15	298	3	Plastic Product Fabrication	None
Cramer Plating	NJ	404023	750025	Stack	6.1	1.8	0.3	14	327	570	Aluminum Etch Tank	None
				Stack	6.1	1.8	0.3	14	322	570	Anodizing Hoist Line	None
				Stack	6.1	1.8	0.3	23	294	180	Ultrasonic Cleaning	None
				Stack	6.1	1.8	0.3	23	294	90	Electrocleaning	None
				Stack	3.0	0.9	0.3	17	293	2000	Zinc Plating	None

TABLE 6-3. (continued)

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM METAL FINISHING

PLANT NAME	STATE	LAT. (DEG, MIN, SEC)	LONG. (DEG, MIN, SEC)	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
East Coast Metal Finishing	NJ	404919	740733	Stack	3.0	2.7	0.91	50	294	590	Electroplating	None
Edmar Creations	NJ	405441	741016	Stack	15	9.0	0.6	15	314	980	Alkaline Soak	None
Miller & Son	NJ	404707	740905	Stack	8.5	5.1	0.6	14	294	280	Electroplating	None
				Stack	8.5	5.1	0.6	15	294	280	Electroplating	None
Moyer Plating	NJ	404359	740846	Stack	6.1	1.8	0.3	29	294	90	Soak Tank	None
Platronics	NJ	403821	741431	Stack	8.5	5.1	0.6	12	294	140	Spray Etching	None
Suffern Plating	NJ	405249	740431	Stack	4.3	3.4	0.8	11	294	290	Metal Cleaning	None
				Stack	4.3	3.9	0.9	11	311	150	Metal Cleaning	None
				Stack	4.3	5.6	1.3	4	294	870	Metal Cleaning; Nickel Plating; Brass Plating	None
Albert's Plating	NY	404313	735608	Stack	6.1	17.7	2.9	17	294	810	Electroclean	None
				Stack	6.7	18.8	2.8	11	294	440	Metal Cleaning	None
Curnow	NY	431046	773936	Stack	7.6	5.3	0.7	16	294	280	Etching	None
General Superplating	NY	430331	760410	Stack	7.6	6.9	0.91	10	294	190	Alk. Cleaning; Metal Plating	None
				Stack	7.6	6.9	0.91	16	294	73	Zinc Plating	None

TABLE 6-3 (continued)

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM METAL FINISHING

PLANT NAME	STATE	LAT. (DEG, MIN, SEC)	LONG. (DEG, MIN, SEC)	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
JHT Plating	NY	404849	735324	Stack	10	51	5.1	4	297	110	Soak Clean, 2 Electroclean Tanks	None
Keystone Corp.	NY	425447	845357	Stack	10	9.1	0.91	13	297	64	Aluminum Etching	None
Levco Metal Finishers	NY	404526	735523	Stack	5.5	4.2	0.76	8.5	311	140	Etching	None
McCauley Inc.	NY	425605	844920	Stack	10	9.1	0.91	13	297	150	Electroclean, Chrome Strip	None
Marlette Plating	NY	425644	845347	Stack	7.3	8.8	1.2	11	333	40	Aluminum Etching	None
				Stack	9.1	8.3	0.91	7	342	130	Alkaline Cleaning	None
				Stack	4.6	1.4	0.3	18	417	95	Black Oxide Bath	None
Monroe Plating	NY	431056	773701	Stack	12	7.3	0.61	13	294	660	Zinc Plating	None
				Stack	12	7.3	0.61	11	294	660	Zinc Plating	None
				Stack	7.9	4.8	0.61	6	339	8900	3 Cleaning Tanks	None
Nelkin Plating	NY	404241	735604	Stack	7.6	20	2.6	11	297	1100	3 Caustic Tanks, Electroclean	None
				Stack	7.3	14	1.9	8.2	297	220	2 Electroclean Tanks	None
				Stack	10	8.0	0.8	4.0	297	560	2 Electroclean Tanks	None
				Stack	9.7	24	2.5	4.9	297	170	2 Electroclean Tanks	None
				Stack	8.5	12	1.4	9.1	297	120	Zinc Plating	None
				Stack	8.5	20	2.3	6.1	297	680	2 Cleaning Tanks	None
				Stack	7.9	16	2.0	8.5	297	310	Caustic Soak Tanks	None
				Stack	7.6	14	1.9	8.5	297	290	Caustic Strike Tank	None
				Stack	8.8	26	3.0	8.8	297	340	Electroclean Tank	None
				Stack	9.4	27	2.9	30	297	680	Electroclean Tank	None

TABLE 6-3. (continued)

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM METAL FINISHING

PLANT NAME	STATE	LAT. (DEG, MIN, SEC)	LONG. (DEG, MIN, SEC)	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Stamplate, Inc.	NY	413556	741849	Stack	2.4	1.5	0.61	2.3	308	55	Electroclean	None
U.S. Electroplating	NY	405019	732022	Stack	6.1	4.3	0.71	6.7	294	73	Electroplating	None
Visu-Craft	NY	425447	845357	Stack	6.4	22	3.5	7.3	294	2900	4 Electrocleaing, 2 Soak Tanks	None
Yonkers Plating	NY	405316	735207	Stack	0.6	0.18	0.3	3.0	294	260	Electroplating	None

6.5 REFERENCES

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7.0 INDUSTRIAL ORGANIC CHEMICALS

7.1 INDUSTRY DESCRIPTION

In 1982, the SIC code 2869 (Industrial Organic Chemicals, Not Elsewhere Classified) had 488 companies and a total of 688 establishments. Three hundred and seventy six plants had at least 20 employees.[1] One hundred and eighty six plants have greater than 100 employees and 62 plants have greater than 500 employees. A list of these 62 plants is given on Table 7-1. This SIC code produces a multiple of products such as acetic, formic and tartaric acids; solvents such as butyl and ethyl alcohol; methanol, synthetic perfumes, artificial flavors, and esters.[3] The only known products in which sodium hydroxide is used are artificial maple flavorings and herbicides. A membership list from The Flavor and Extract Manufacturers' Association of the United States was also obtained.

7.2 PROCESS DESCRIPTION

This section describes the processes used at two plants that are the only plants in this SIC code known to emit sodium hydroxide. One plant uses sodium hydroxide in the production of artificial maple flavoring. Figure 7-1 shows the processes used at Elan Chemical. The Flavoring and Extract Manufacturer Association expects the number of plants that produce this flavor to be small. Also, the Association did not know how frequent caustic soda is used by its members to produce flavors and extracts.[4]

At this plant, a 25% caustic soda solution and corn cobs are the raw materials used. All processes are batch processes. The raw materials are preheated in a 1500 gallon container with approximately 8 percent by weight of the reactor's content being sodium hydroxide. Caustic soda breaks down the cellulose fibers in the corn cob similar to what is done in paper manufacturing. The preheater contents are then pumped to a 1500 gallon reactor which oxidizes the corn cobs under pressure using compressed air. Retention time in the reactor is 6-8 hours. After oxidizing the corn cobs, the contents are pumped to one of three closed-top 6-7,000 gallon holding tanks prior to shipment.[5]

TABLE 7-1. INDUSTRIAL ORGANIC CHEMICALS - U.S. PLANTS WITH GREATER THAN 500 EMPLOYEES[2]

Plant Name	Location
ASAG Incorporated	Harriman, NY
Advanced Nuclear Fuels Corp.	Bellevue, WA
Advanced Nuclear Fuels Corp.	Richland, WA
Akzo America Inc.	New York, NY
Akzona Incorporated	New York, NY
Aldrich Chemical Company Inc.	Milwaukee, WI
American Cynamid Co., Inc.	Westwego, LA
Amoco Performance Products In.	Ridgefield, CT
Angus Chemical Company	Sterlington, LA
Angus Chemical Company	Northbrook, IL
The Babcock & Wilcox Co.	Holcombs Rock, VA
BASF American Corp.	Parsippany, NJ (2 plants)
BASF American Corp.	Clifton, NJ
Borg-Warner Chemical Inc.	Parkersburg, WV
Buckman Laboratories Inc.	Memphis, TN
Celanese Chemical Company Inc.	Dallas, TX
Celanese Construction Fabrics	New York, NY
Chemed Corporation	Baltimore, MD
Chesebrough-Ponds Inc.	Adrian, MI
Degussa Corporation	Teterboro, NJ
Degussa Corporation - Alabama Group	Theodore, AL
Detrex Corporation	Southfield, MI
The Dow Chemical Co.	Freeport, TX (2 plants)
The Dow Chemical Co.	Lake Jackson, TX
The Dow Chemical Co.	Houston, TX
The Dow Chemical Co.	Indianapolis, IN
Dravo Corporation	Pittsburgh, PA
Eastman Kodak Company	Kingsport, TN
Ferro Corporation	Cleveland, OH
Grain Processing Corporation	Muscatine, IA
International Flavors/Fragrances	Union Beach, NJ
International Mineral Chemical	Terre Haute, IN
M & T Chemicals Inc.	Woodbridge, NJ
Miles Laboratories	Elkhart, IN
Monsanto Company	St. Louis, MO
Monsanto Company	East St. Louis, IL
The Nutrasweet Company	Skokie, IL
Occidental Chemical Corp.	Niagara Falls, NY (2 plants)
Occidental Chemical Holding	Los Angeles, CA
Oxy Chemical Corporation	Los Angeles, CA (2 plants)
P M C Inc.	Chicago, IL
PPG Industries Inc.	New Martinsville, WV
Sherex Chemical Company Inc.	Dublin, OH
Shipley Company Inc.	Newton, MA

TABLE 7-1. INDUSTRIAL ORGANIC CHEMICALS - U.S. PLANTS WITH GREATER THAN 500 EMPLOYEES[2] (Continued)

Plant Name	Location
Signal Companies Inc.	Des Plaines, IL
Signal Companies Inc.	La Grange, IL
Standard Oil Chemical Company	Cleveland, OH
Texaco Chemical Company	Bellaire, TX
Texaco Inc.	Port Arthur, TX
Texas Petrochemicals Corp.	Houston, TX
Union Carbide Corporation	Institute, WV
Union Carbide Corporation	S. Charleston, WV
Union Carbide Corporation	Seadrift, TX
Union Carbide Corporation	Danbury, CT
Union Carbide Corporation	Charleston, WV
Uniroyal Plastics Co. Inc.	Middlebury, CT
Wacker Siltronic Corporation	Portland, OR

Another plant in this SIC Code (Fermenta Plant Protection) uses a 30% caustic soda solution in the production of sodium arsenite, an ingredient used to produce the herbicide, monosodium methylarsenate. The solution is produced at the plant from anhydrous caustic soda. The caustic soda solution along with arsenic trioxide is charged to a reactor vessel, 8 feet in diameter and 8 feet high with a capacity of 2500 gallons. The process produces sodium arsenite and is operated at ambient conditions. The reaction is slightly exothermic. The process is operated 8 hours per day, 5 days per week. Six to eight batches are processed daily.[6]

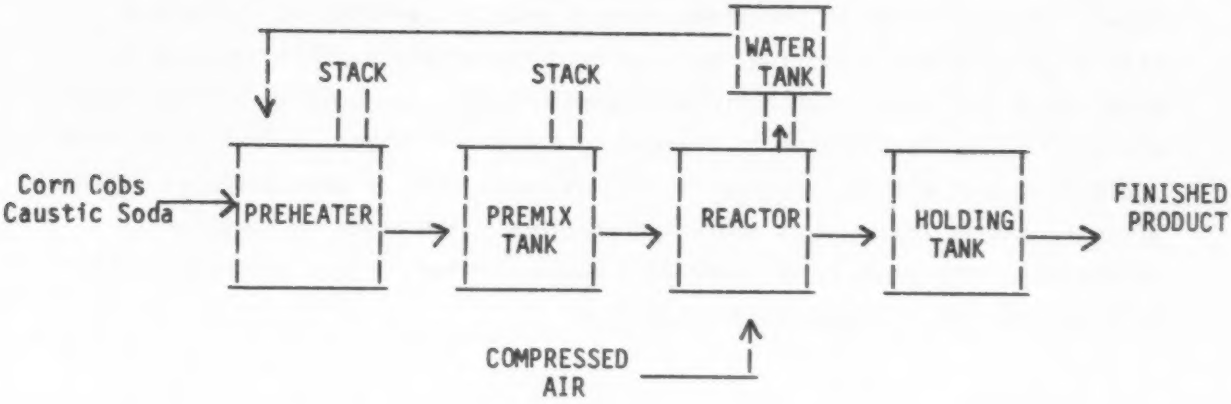
7.3 EMISSIONS

At Elan Chemical, emissions from the preheater, premix tanks and holding tanks are ducted to the atmosphere with no controls through separate stacks. Air releases from the reactor are quenched by a 5000 gallon water tank that condenses steam and caustic vapor as well as serving as a heat exchanger. The tank contents are then transferred to the preheater tank. There are no air releases to the atmosphere from this reactor. Also, air is exhausted from the building to prevent vapor build-up.[5]

At Fermenta Plant Protection, emissions from the reactor result from the violent spraying of caustic solutions. Emissions are controlled by a Brinks mist eliminator that occasionally uses caustic soda or water as the scrubbing medium. The mist eliminator is used to limit arsenic emissions as well as for product recovery.[6]

7.4 HEM INPUTS

The HEM Inputs for Elan Chemical and Fermenta Plant Production are given in Table 7-2. These inputs were obtained from printouts received from the States of New Jersey and Texas.



WATER TANK
STACK
STACK
Corn Cobs
Caustic Soda
PREHEATER
PREMIX TANK
REACTOR
HOLDING TANK
FINISHED PRODUCT
COMPRESSED AIR

Figure 7-1. Production of Maple Flavoring - Elan Chemical, Newark, NJ[5]

TABLE 7-2.

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM INDUSTRIAL ORGANIC CHEMICALS

PLANT NAME	STATE	LAT.	LONG.	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
		(DEG, MIN, SEC)										
Elan Chemical	NJ	404326	740725	Stack	6.0	0.36	0.06	1.0	320	2050	Preheater	None
				Stack	6.0	0.36	0.06	1.0	320	2050	Premix Tank	None
				Stack	7.8	0.47	0.06	1.6	300	2730	3 Holding Tanks	None
				Stack	6.0	1.6	0.27	15.0	290	45	Building Exhaust	None
Fermenta Plant Protection Company	TX	294549	951006	Stack	12.0	4.6	0.38	12.0	300	45	Sodium Arsenite Reactor	Mist Eliminator

7.5 REFERENCES

1. Bureau of the Census, U.S. Department of Commerce. 1982 Census of Manufactures - General Summary Part 1. MC 82-S-1 (Part 1). Washington, DC. March 1986. p. 1-10.

2. Duns Electronic Yellow Pages - Manufacturers. File 510. April 1987.

3. The Statistical Policy Division, Office of Management and Budget. Standard Industrial Classification Manual, 1972. Washington, DC. 1972. pp. 122-123.

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8.0 SOAP AND DETERGENT MANUFACTURING

8.1 INDUSTRY DESCRIPTION

This chapter covers SIC Code 2841 - Soap and other detergents, except specialty cleaners. This category includes plants primarily engaged in manufacturing soap, synthetic organic detergents, inorganic alkaline detergents, or any combination thereof, and establishments producing crude and refined glycerin from vegetable and animal fats and oils.[1] In 1982, there were 642 companies in this category with 723 plants. Two hundred and thirty two plants have 20 or more employees.[2] A list of those plants with greater than 100 employees is shown on Table 8-1. Table 8-2 shows the spray dry detergent manufacturers that were operating in 1980.[4]

8.2 PROCESS DESCRIPTION

8.2.1 General - Soap

Soap consists of various mixtures of sodium or potassium salts of fatty acids. Soap can be manufactured by either a batch or continuous process, using either the alkaline saponification (converting fats to soap) using natural fats and oils or the direct saponification of fatty acids.[5]

Much of the world production is still produced in batch processes that use open steel kettles. Processing rates per batch vary from several thousand to several hundred thousand pounds of soap. Fats and oils are converted to soap by direct or indirect steam heating in a caustic solution. The end product from the kettles is a completely saponified neutral soap containing approximately 30% water. Dry salt is added to the boiling soap until a hard grain is obtained. After a short boil, the kettle contents are allowed to separate for several hours. The bottom layer, consisting primarily of caustic, glycerol, and salt is pumped to storage tanks prior to recovering the glycerol and salt in separate concentrating and refining operations. The upper soap layer, is washed to remove colored and odorous impurities as well as to separate glycerol and salt from the soap.[6]

Continuous alkaline saponification of natural fats and oils as well as fatty acids has the same processes as batch processes but process time is shortened. Fatty acids obtained by continuous hydrolysis usually are neutralized with caustic soda in a high speed mixer/neutralizer to form soap.[5]

TABLE 8-1. SOAP AND DETERGENT MANUFACTURING - U.S. PLANTS WITH GREATER THAN 100 EMPLOYEES[3]

Plant Name	Location
Amerchol Corporation	Edison, NJ
American Hospital Supply Corp.	El Paso, TX
American Soap Company Inc.	Olive Branch, MS
Analytab Products	Plainville, NY
Armour and Company	Phoenix, AZ
Barcolene Company Inc.	Holbrook, MA
Bonner W C Co. Inc.	Watertown, MA
Calgon Corp.	St. Louis, MO
Calusa Chemical Company Inc.	Santa Fe Springs, CA
Chemed Corporation	Cincinnati, OH
Colgate-Palmolive Company	Piscataway, NJ
Colgate-Palmolive Company	Kansas City, KS
Colgate-Palmolive Company	New York, NY
Colgate-Palmolive Company	Clarksville, IN
Desoto Inc.	Fort Worth, TX
Desoto Inc.	Union City, CA
Dial Corporation	St. Louis, Mo
Dial Corporation	Chicago, IL (2 plants)
Dial Corporation	Omaha, NE
Dial Corporation	Bristol, PA
Dial Corporation	Auburndale, FL
Dial Corporation	Montgomery, IL
Diamond Chemical Co. Inc.	Lyndhurst, NJ
Ecolab Inc.	St. Paul, MN
Emhart Corporation	Middleton, MA
Glissen Chemical Co. Inc.	Brooklyn, NY
Go-Jo Industries Inc.	Cuyahoga Falls, OH
Hewitt Soap Co.	Dayton, OH
Huish Chemical Co.	Salt Lake City, UT
Industrial Chemical Labs	Omaha, NE
Andrew Jergens Company	Cincinnati, OH
Kleen Brite Laboratories Inc.	Rochester, NY
Knomark Inc.	Queens, NY
Korex Company	Wixom, MI
Lever Brothers Company	Los Angeles, CA
Lever Brothers Company	Hammond, IN
Lever Brothers Company	Whiting, IN
Lever Brothers Company	St. Louis, MO
Lever Brothers Company	New York, NY
Lever Brothers Company	Baltimore, MD
Los Angeles Soap Company	Los Angeles, CA
Minnesota Mining and Mfg.	St. Paul, MN
Minnestonka Inc. Soft Soap	Chaska, MN
Mo-Kan Manufacturing Company	Kansas City, MO
Mohawk Supply Co.	Sparta, NJ
Monsanto Chemical Company	Trenton, MI

TABLE 8-1. SOAP AND DETERGENT MANUFACTURING - U.S. PLANTS WITH GREATER THAN 100 EMPLOYEES[3] (Continued)

Plant Name	Location
National Chemical Labs PA	Philadelphia, PA
National Distillers & Chemical	Los Angeles, CA
O'Brien Corporation	South Bend, IN
Original Bradford Soap Works	West Warwick, RI
Pfanstiehl Detergent Chem.	Hinsdale, IL
Pilot Chemical Corp.	Santa Fe Springs, CA
Procter & Gamble Company	Cincinnati, OH (3 plants)
Procter & Gamble Company	Levelland, TX
Procter & Gamble Company	Sacramento, CA
Procter & Gamble Company	Jacksonville, FL
Procter & Gamble Company	Orange, CA
Procter & Gamble Company	Dallas, TX
Procter & Gamble Company	Quincy, MA
Procter & Gamble Company	Richmond, NY
Procter & Gamble Company	Baltimore, MD
Procter & Gamble Company	Augusta, GA
Procter & Gamble Company	Kansas City, KS (2 plants)
Procter & Gamble Company	Long Beach, CA
Procter & Gamble Company	St. Louis, MO
Rickert Ben Inc.	Wayne, NJ

TABLE 8-2. SPRAY-DRY DETERGENT MANUFACTURERS, 1980[4]

Company	Location
The Procter and Gamble Company	Long Beach, California Sacramento, California Augusta, Georgia Kansas City, Kansas Alexandria, Louisiana Baltimore, Maryland Quincy, Massachusetts New York, New York Cincinnati, Ohio Dallas, Texas
The Colgate-Palmolive Company	Berkeley, California Jeffersonville, Indiana Kansas City, Kansas Jersey City, New Jersey
Lever Brothers	Los Angeles, California Baltimore, Maryland St. Louis, Missouri
Astor Products	Jacksonville, Florida
Chemithon	Seattle, Washington
Custom Spray Products, Inc.	Atlanta, Georgia
The Great Atlantic and Pacific Tea Company, Inc.	Brockport, New York
Los Angeles Soap Company	Los Angeles, California
Luseaux Labs	Gardena, California
National Purity Soap and Chemical Company	Minneapolis, Minnesota
Pacific Soap	San Diego, California
Plex Chemicals	Union City, California
Purex	Southgate, California St. Louis, Missouri Bristol, Pennsylvania
Safeway Stores, Inc.	Oakland, California
Stepan Chemical	Chicago, Illinois
Witco Chemical Corporation	Chicago, Illinois Paterson, New Jersey

A diagram of a continuous process is shown on Figure 8-1. In this process, a fat/oil mixture is pumped through a sprayer into the bottom of closed hydrolyzer operating at 600 - 700 psi and 485°F. Hot water is introduced near the top of the tower to produce fatty acids. These acids are then refined by vacuum distillation. The fatty acids are continuously mixed in a high speed blender with a 50% sodium or potassium hydroxide solution.[7]

The end product of both the kettle and continuous process is called "neat soap" and contains approximately 30% moisture. The soap slurry is dryed in either a cabinet, flash or vacuum dryer. For bar soaps, 10-15 percent moisture is specified prior to cooling and extruding. Water content must be reduced to 5-10% before cutting into flakes.[6]

8.2.2 Specific Processes of Interest - Soap

As shown on Table 8-3, the only processes known to emit sodium hydroxide are kettles and material handling process units.

Kettles used in the soap manufacturing industry are circular or square in cross section and are tapered to cones at the bottom. Kettle operation is generally lagged to conserve heat. Open steam coils in the cone section supply heat and agitation. Closed steam coils may also be present to supply heat without adding steam.[6]

Information was obtained on Chemed Corporation's East Rutherford, New Jersey plant that uses kettles to produce liquid soap. This plant has 11 batch kettles that range in size from 500 - 5,000 gallons. Kettle dimensions vary from 4 1/2 - 8 1/2 feet in diameter and 5 - 10 feet in depth. All kettles have closed tops except for a 5 square foot bar grate area where material is added to the kettle. The kettle initially begins operating at ambient temperature and heat could be evolved during the mixture of certain products. Cooling jackets surround the kettles and no external heat is added. The average sodium hydroxide content of the batch for those liquid soap products that require sodium hydroxide is 20 percent. In 1986, 368,000 gallons of 50 percent caustic soda was used by the company in the production of liquid soaps. Products are made to order and retention time in the kettles vary from 1 to 24 hours. In 1986, approximately 2,500 batches were produced.

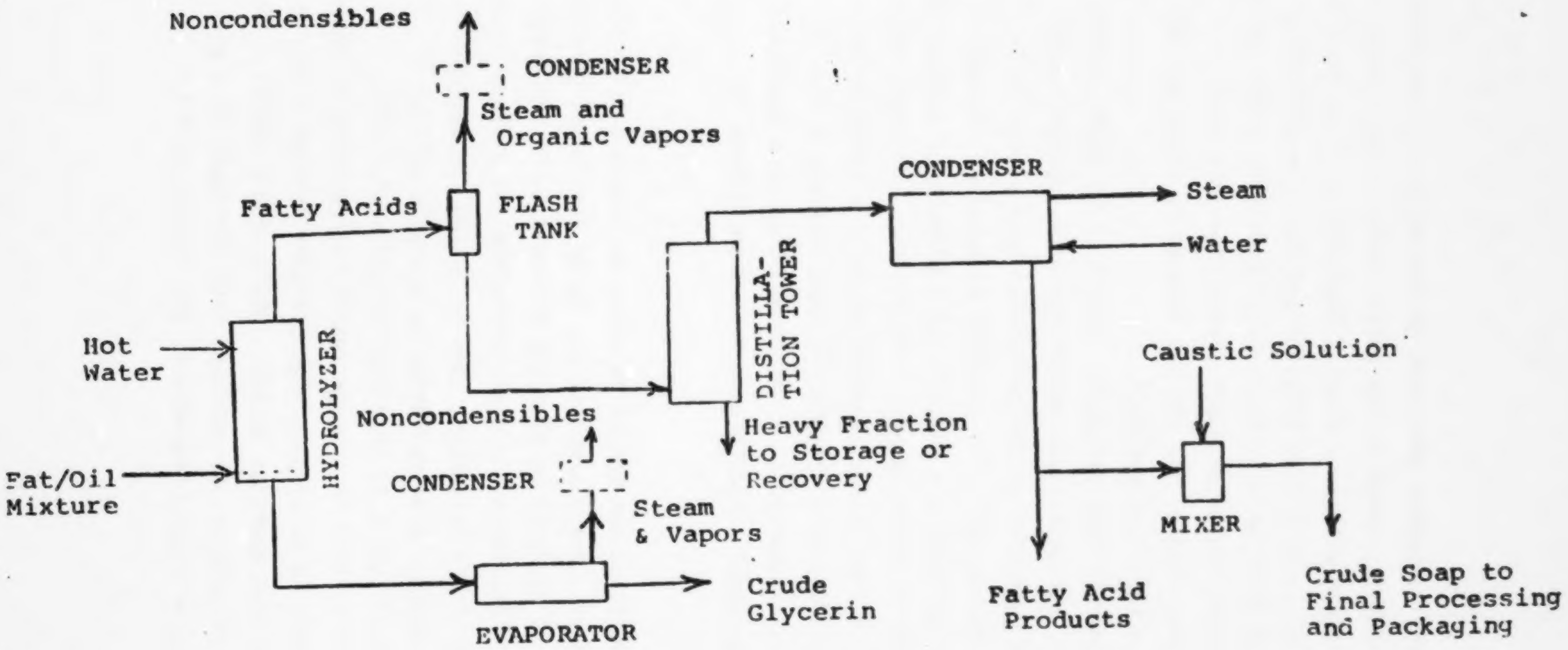
Noncondensibles
CONDENSER
Steam and
Organic Vapors
Fatty Acids
FLASH
TANK
CONDENSER
Steam
Water
Hot
Water
HYDROLYZER
DISTILLA-
TION TOWER
Caustic Solution
Noncondensibles
Heavy Fraction
to Storage or
Recovery
Fat/Oil
Mixture
CONDENSER
MIXER
Steam
& Vapors
Crude
Glycerin
Fatty Acid
Products
Crude Soap to
Final Processing
and Packaging
EVAPORATOR

Figure 8-1. Continuous Process for Manufacture of Fatty Acids and Soap[7]

The kettle process generally begins when part of the weighed coconut-oil fraction of the fat charge is first added to the kettle with a little water and salt, and heated and agitated with live steam. Saponification is usually started by the addition of 50% caustic soda solution and the slow addition of the remaining coconut oil. A small amount of dry salt is usually added during the process to maintain a slight excess of electrolyte. The last small caustic soda additions are made slowly. As the pan expands by steaming, the "closed grin" is tested for alkali consumption.[6]

At Chemed, dry soap powder is also produced. Caustic soda beads, soda ash, sodium tripolyphosphate, sodium sulfate and tetrasodium pyprophosphate are added in various amounts depending on the particular soap powder to be produced. These materials are pneumatically conveyed to separate storage silos. All material except the beads are placed into a blowpot (a pressurized vessel) up to a maximum amount of 5,000 pounds. The caustic soda beads are weighed and conveyed to one of four ribbon blenders which also receives the blowpot product. The blenders are long troughs; 10 feet long and 4 feet wide. The blended product is discharged to a hopper and then to a packaging station where products are packaged in containers from 2 pound bags to 55 gallon drums.[8]

8.2.3 General-Detergent

The manufacture of spray dried detergents is shown on Figure 8-2.[5] There are three main processing steps: slurry preparation, spray drying and granule handling. Detergent slurry is produced by blending a liquid surfactant with powdered and liquid materials (builders and other additives) in a closed mixing tank called a crutcher. The liquid surfactant used in making the detergent slurry is produced by the sulfonation or sulfation by sulfuric acid of a linear alkylate or a fatty acid, which is then neutralized with caustic solution. The blended slurry is held in a surge vessel for continuous pumping to the spray dryer. The slurry is sprayed at high pressure through a nozzle into a vertical drying tower that operates at 315 - 400°C (600 - 750°F). The detergent granules are mechanically or air conveyed from the tower to a mixer to incorporate additional dry or liquid ingredients and finally sent to packaging and storage.[5]

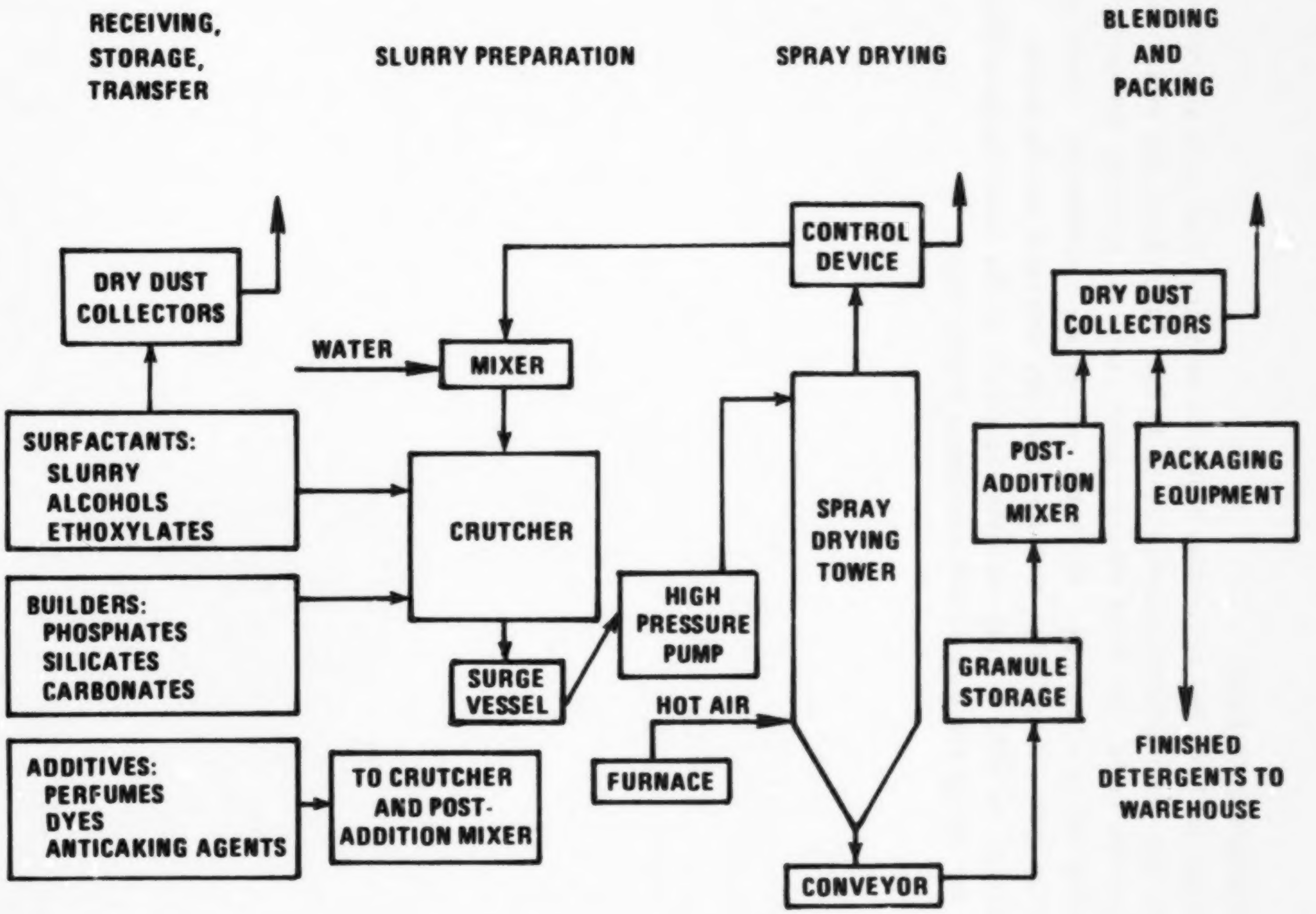
RECEIVING,
STORAGE,
TRANSFER
SLURRY PREPARATION
SPRAY DRYING
BLENDING
AND
PACKING
DRY DUST
COLLECTORS
CONTROL
DEVICE
DRY DUST
COLLECTORS
WATER
MIXER
SURFACTANTS:
SLURRY
ALCOHOLS
ETHOXYLATES
CRUTCHER
SPRAY
DRYING
TOWER
POST-
ADDITION
MIXER
PACKAGING
EQUIPMENT
BUILDERS:
PHOSPHATES
SILICATES
CARBONATES
HIGH
PRESSURE
PUMP
SURGE
VESSEL
HOT AIR
GRANULE
STORAGE
ADDITIVES:
PERFUMES
DYES
ANTICAKING AGENTS
TO CRUTCHER
AND POST-
ADDITION MIXER
FURNACE
FINISHED
DETERGENTS TO
WAREHOUSE
CONVEYOR

Figure 8-2. Spray Dried Detergent Manufacturing[5]

8.3 EMISSIONS/HEM INPUTS

Shown on Table 8-3 are sodium hydroxide emissions that were estimated for one soap manufacturing plant, Chemed in East Rutherford, New Jersey. As noted in the table, the first emission point (material handling and storage) is controlled by a baghouse. All batch kettles are uncontrolled. There were no sodium hydroxide emission data for spray-dry detergent manufacturing. The information in Table 8-3 was submitted as imputs to the Human Exposure Model (HEM) for use by EPA's Pollutant Assessment Branch (PAB).

TABLE 8-3.

HEM INPUTS - SODIUM HYDROXIDE EMISSIONS FROM SOAP MANUFACTURING

PLANT NAME	STATE	LAT.	LONG.	EMISSION TYPE	STACK HEIGHT (M)	VERTICAL AREA (SQ. M.)	STACK DIAMETER (M)	STACK VELOCITY (M/S)	STACK TEMP. (°K)	NaOH EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Chemed Corp.	NJ	404922	740547	Stack	9.9	6.8	0.69	9.8	294	3300	Storage Silo, Tote bin, Ribbon blenders, product hoppers, packaging stations	Baghouse
				Stack	12	6.1	0.51	11.0	294	950	11 Batch Kettles	None
				Stack	11	3.6	0.33	11.0	294	950	3 Batch Kettles	None
				Stack	11	3.0	0.27	16.2	300	950	5 Batch Kettles	None

8.4 REFERENCES

1. The Statistical Policy Division, Office of Management and Budget. Standard Industrial Classification Manual 1972. Washington, DC. 1972. p. 118.

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6. Ryder, F.V. Soap. In: Kirk-Othmer Encyclopedia of Chemical Technology, Volume 18. New York, John Wiley and Sons, Inc. 1964. pp. 415-431.

7. Environmental Engineering, Inc. and PEDCO Environmental Specialists, Inc. Draft Background Information for Establishment of National Standards of Performance for New Sources - Soap and Detergent Industry. Prepared for U.S. Environmental Protection Agency. Raleigh, North Carolina.

8. Telecon. Rice, V.W., DuBois Chemical with Neuffer, W.J., U.S. EPA. May 29, and June 1, 1987. Process information on Chemed Corporation plant in East Rutherford, New Jersey.

9.0 METAL PARTITIONS, SHELVING, RACKS

9.1 INDUSTRY DESCRIPTION

This chapter discusses SIC Code 2542 - Metal Partitions, Shelving, Lockers, and Office and Store Fixtures. Plants in this SIC code manufacture metal products such as counters, display cases, gourmet racks, partitions, and shelves.[1] In 1982, this SIC had 533 companies with 568 plants. Two hundred and ninety nine of these plants had at least 20 employees.[2] One hundred and sixty one plants have greater than 100 employees. A list of the 18 plants in this SIC code with greater than 500 employees is shown on Table 9-1.

9.2 PROCESS DESCRIPTION

It is uncertain how many of the 568 plants in this SIC code use sodium hydroxide at their facilities. According to one plant representative, many plants would contract metal plating to job shops that are discussed in Chapter 6 - Metal Finishing.[4] Telephone calls were made to eight plants that are members of the Rack Manufacturing Institute or the National Association of Display Industries. Two plants use caustic soda and one uses it only to regenerate resins from a water deionizer.

Specific process information was obtained from three other plants that use sodium hydroxide. Ferro Merchandizing Equipment, Union, New Jersey, manufactures metal displays and racks that, for example, are used in department stores for clothing displays. The plant has two plating lines; one that is operated manually and the other automatic. A process flow diagram is shown in Figure 9-1 for a plating line at this plant.

All tanks have approximately identical capacities of 800 gallons and dimensions of 3 feet wide, 9 feet long, and 5 feet deep. The process is a batch type with each metal batch weighing 75-100 pounds and a retention time of 30 seconds per tank. More detailed descriptions of the soak cleaning and electrocleaning processes are contained in Chapter 6.

The only tanks that use sodium hydroxide are the electroclean and activator tanks. For the electroclean tanks, a 60% caustic soda powder is used at a rate to produce a 6% total bath concentration of the powder in the

TABLE 9-1. SIC 2542 - U.S. PLANTS WITH GREATER THAN 500 EMPLOYEES[3]

PLANT NAME	LOCATION
American Desk Manufacturing Company	Temple, TX
Bali Company	Winston-Salem, NC
Forsyth International, Limited	Cumming, GA
Hauserman Incorporated	Cleveland, OH
Hayworth Incorporated	Holland, MI
Lozier Corporation	Omaha, NE (2 plants)
LTV Steel Company	Salem, NH
Lyon Holding Company	Aurora, IL
Madix Incorporated	Terrell, TX
Reflector - Hardware Corporation	Melrose Park, IL
Republic Storage Systems Company	Canton, OH
SPS Technologies Incorporated	Santa Ana, CA
Sunarhauserman Incorporated	Cleveland, OH
Syndicate Systems Incorporated	Indianapolis, IN
Tab Products Company	Palo Alto, CA
U.S. Providence Corporation	Providence, RI
Unarco Industries Incorporated	Chicago, IL
Vespar Corporation	Bala-Cynwyd, PA

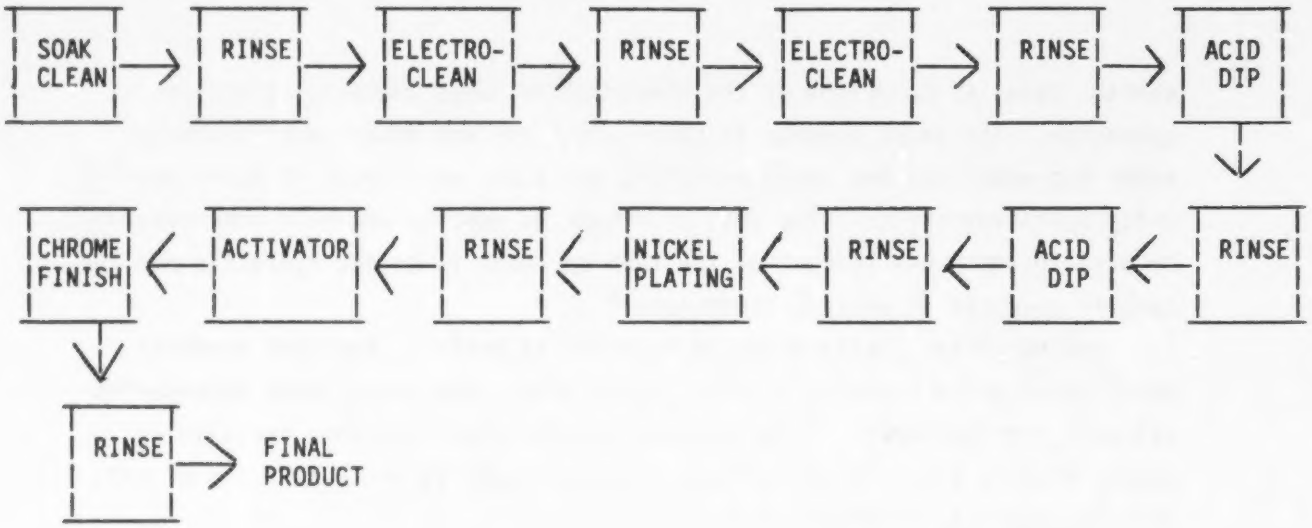

SOAK CLEAN
RINSE
ELECTRO-CLEAN
RINSE
ELECTRO-CLEAN
RINSE
ACID DIP
RINSE
ACID DIP
RINSE
NICKEL PLATING
RINSE
ACTIVATOR
CHROME FINISH
RINSE
FINAL PRODUCT

Figure 9-1. Plating Line - Ferro Merchandising Equipment - Union, New Jersey[4]

tanks. Thus, 4% by weight of the electroclean tanks contents is sodium hydroxide. The tanks operate at 150 - 170°F and are dumped approximately every two weeks for one daily operating shift and every week if there are 2-3 daily operating shifts. The activator tank is used to assure chrome coverage on metal parts. One percent of the tank contents is sodium hydroxide and the tank is operated at ambient conditions.[4]

Another plant, Smith-McDonald Products in Buffalo, New York produces metal fabrication products such as letter trays, ash trays, desk accessories and mail sorting racks. Fifty percent caustic soda solutions are used in copper plating and to blacken brass. Caustic soda is added at rates of 1/2 and 12 oz/gallon, respectively.[5]

Republic Storage Systems, Canton, Ohio, has a small zinc plating operation, using caustic soda, where latches and lock parts, contained in barrels, are plated 2-3 days/week. Also, a ferric phosphate cleaning system that has sodium hydroxide removes oil from coil metal products prior to metal fabrication. Caustic soda is also used to backflush resins used to deionize water.[6]

9.3 EMISSIONS/HEM INPUTS

Based on printouts received from the States of Kentucky, New Jersey, New York and Texas, only two metal partition/shelving rack plants located in these States have sodium hydroxide air emission estimates. These estimates and stack parameters for emission sources at these two plants are shown on Table 9-2.

TABLE 9-2.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM METAL PARTITIONS

PLANT NAME	STATE	LAT.	LONG.	EMISSION TYPE	HEIGHT (M)	VERTICAL AREA (SQ. M.)	DIAMETER (M)	VELOCITY (M/S)	TEMP. (°K)	EMISSIONS (Kg/yr)	SOURCE DESCR.	CONTROL DEVICE
Ferro Merchandising Equipment Corp.	NJ	404007	741330	STACK	7.5	7.6	0.75	12	300	930	3 Electroclean Tanks	None
				STACK	6.9	21.0	3.1	6.6	300	3,900	2 Electroclean Tanks, 2 Soak Clean Tanks	None
Smith-McDonald Products Corp.	NY	425433	844511	STACK	7.2	4.7	0.65	14	330	100	Plating	None
				STACK	7.2	3.2	0.45	8.1	290	91	Plating	None

9.4 REFERENCES

1. The Statistical Policy Division, Office of Management and Budget. Standard Industrial Classification Manual 1972. Washington, DC. 1972. p. 99.

2. Bureau of the Census, U.S. Department of Commerce. 1982 Census of Manufactures - General Summary Part 1. MC-82-S-1 (Part 1). Washington, DC. March 1986. p. 1-8.

3. Duns Electronic Yellow Pages - Manufacturers. File 510. April 1987.

4. Telecon. Dimattia, F., Ferro Mechandising Equipment with Neuffer, W.J., U.S. EPA. July 10, 1987. Process information on Union, New Jersey plant.

5. Telecon. Rotando, H. Smith-McDonald Products Company with Neuffer, W.J., U.S. EPA. July 24, 1987. Process information on Buffalo, New York plant.

6. Telecon. Eshbach, B. Republic Storage Systems with Neuffer, W.J., U.S. EPA. July 28, 1987. Process information on Canton, Ohio plant.

10.0 MISCELLANEOUS INDUSTRIES

10.1 SUMMARY

Based on computer printouts received from the States of Kentucky, New Jersey, New York, and Texas, there are numerous industries with estimated sodium hydroxide emissions less than 10,000 lb/yr. Plants with sodium hydroxide emissions between 1,000 - 10,000 lb/yr and not in SIC codes discussed in Chapters 3-9 are summarized in tables in this chapter. There are numerous other plants in these States with emissions below 1,000 lb/yr. Due to the lower emissions from these sources, compared to plants in prior chapters, little time was expended to verify these estimates. Some New Jersey plants are not included in tables for this chapter as most emissions are from NaOH storage tanks which are now considered to be minor. Table 10-1 presents the five plants in the four States with estimated sodium hydroxide emissions greater than 5,000 lb/yr (2,300 kg/yr) but less than 10,000 lb/yr (4,500 kg/yr).

Table 10-2 shows the 25 plants in New York, Kentucky, and Texas that have sodium hydroxide emissions between 1,000 - 5,000 lb/yr. There are 22 different SIC codes in this table with SIC 3429 (Hardware) having three plants and SIC 3811 (Engineering and Scientific Instruments) having 2 plants. Most emission sources are electroplating, metal cleaning or etch tanks. Only three plants have emission control equipment, two with wet scrubbers and one with a mist eliminator.

Table 10-3 summarizes the 29 plants in New Jersey with sodium hydroxide emissions between 1,000 - 5,000 lb/yr. There are 22 different SIC codes with the following SIC codes having more than one plant: 2816 (Inorganic Pigments) - 3; 2819 (Industrial Inorganic Chemicals) - 4; 2821 (Plastic Materials) - 2; and 3341 (2° Nonferrous Metals) - 2. Process units in these plants that cause these emissions and any control equipment used were not identified in the printout received from New Jersey.

TABLE 10-1. PLANTS WITH SODIUM HYDROXIDE EMISSIONS BETWEEN 5,000 - 10,000 lb/yr

SIC CODE	INDUSTRY	COMPANY	LOCATION	EMISSIONS lb/yr (kg/yr)	SOURCE DESCRIPTION	CONTROL EQUIPMENT
3325	Steel Foundries	General Electric	Schenectady, NY	5,300 (2,400)	Rinse Tank	None
2834	Pharmaceutical Preparations	EM Diagnostic	Greenwich Township, NJ	8,800 (4,000)	4 Filling Lines	None
3911	Jewelry, Precious Metals	PM Refining	Buffalo, NY	5,400 (2,500)	2 Gold Melting Furnaces	Packed Tower Scrubber
				870 (400)	3 Gold Melting Furnaces	None
3542	Machine Tools	Chicago Pneumatic Tools	Frankfort, NY	6,000 (2,700)	Rust Stripping Tank	None
3568	Power Transmission Equipment	Bendix Fluid Power	Utica, NY	5,800 (2,600)	Alkaline Cleaning	None

TABLE 10-2. PLANTS IN KENTUCKY, NEW YORK, AND TEXAS WITH SODIUM HYDROXIDE EMISSIONS BETWEEN 1,000 - 5,000 lb/yr

SIC CODE	INDUSTRY	COMPANY	LOCATION	EMISSIONS lb/yr (kg/yr)	SOURCE DESCRIPTION	CONTROL EQUIPMENT
3200	Stone, Clay and Glass	Corning	Erwin, NY	4,500 (2,050)	Nickel Plating	None
2819	Industrial Inorganic Chemicals	American Chrome and Chemical	Corpus Christi, TX	4,400 (2,000)	Chromic Acid Plant	Wet Scrubber
3572	Typewriters	SCM	Cortland, NY	4,200 (1,900)	Cleaning Tanks	None
3811	Eng. and Sci. Instruments	Abbott Labs.	Irving, TX	4,000 (1,800)	Chemical Manu.	None
3714	Motor Vehicle Parts	Sealed Power	Franklin, KY	3,500 (1,600)	Rust Strip Tanks	None
3429	Hardware	Weber-Knapp	Jamestown, NY	3,200 (1,500)	Aluminum Etching	None
3574	Calculating Machines	NCR	Ithaca, NY	3,100 (1,410)	Plating	None
3078	Misc. Plastic Parts	Owens-Illinois	Bardstown, KY	3,000 (1,360)	Industrial Washing	None
3452	Nuts & Bolts	Crest Products	Lexington, KY	2,500 (1,100)	Electrocleaning	None
3496	Fabricated Wire	Plymouth Tube	Hopkinsville, KY	2,200 (1,000)	Electroplating	Wet Scrubber
3442	Metal Doors	Hopes	Jamestown, NY	2,100 (950)	Caustic Dip Tank	None
6512	Non-Resid. Bldg.	Ideal Corp.	Brooklyn, NY	1,900 (860)	Plating	None
3429	Hardware	Chautauqua	Jamestown, NY	1,800 (820)	Electrocleaning	None

TABLE 10-2. PLANTS IN KENTUCKY, NEW YORK, AND TEXAS WITH SODIUM HYDROXIDE EMISSIONS (Continued)

SIC CODE	INDUSTRY	COMPANY	LOCATION	EMISSIONS lb/yr (kg/yr)	SOURCE DESCRIPTION	CONTROL EQUIPMENT
3629	Electrical Industrial Apparatus	LRC Electronics	Chemung Co., NY	1,700 (770)	Etch Tank	None
3717	Motor Vehicle	Ford Motor	Green Island, NY	1,600 (730)	Dip Tank	None
3573	Electronic Computing	IBM	Endicott, NY	1,500 (680)	Stripping, Etching	None
3811	Eng. and Sci. Instruments	Singer Colink	Kirkwood, NY	1,400 (640)	Aluminum Deoxidize	None
3613	Switch Gears	Square D	Lexington, KY	1,400 (640)	Cadmium Plating	Mist Elim.
3429	Hardware	Union Fork & Hoe	Frankfort, NY	1,200 (550)	Wash Tanks, Aluminum Etching	None
3662	Radio & TV Equip.	IBM	Owego, NY	1,200 (550)	Copper Plating	None
3679	Electronic Comp.	Hadco Print	Owego, NY	1,200 (550)	Solder Stripping	None
3479	Metal Coating	Universal Fasteners	Lawrenceburg, KY	1,200 (550)	Metal Plating	None
3497	Metal Foil	Park Nameplate	Flushing, NY	1,200 (550)	Curing Ovens	None
3742	Railroad Equip.	NY Air Brake	Watertown, NY	1,100 (500)	De-rusting	None
1950	Wash & Clean Minerals	C. G. Phillips	Seneca Falls, NY	1,100 (500)	Dip Tanks	None

TABLE 10-3. NEW JERSEY PLANTS WITH SODIUM HYDROXIDE EMISSIONS BETWEEN 1,000 - 5,000 lb/yr

SIC CODE	INDUSTRY	COMPANY	LOCATION	EMISSIONS lb/yr (kg/yr)
2823	Cellulosic Man-Made Fibers	Hercules	Sayreville	4,400 (2,000)
2842	Polishes, Cleaning & Sanitation Goods	Witco Chemical	Paterson	3,800 (1,700)
3562	Ball & Roller Bearing	Roller Bearing Co.	Ewing	3,800 (1,700)
2816	Inorganic Pigments	Ciba Geigy	Dover	3,600 (1,600)
3341	2° Nonferrous Metals	Engelhard Minerals	Newark	2,600 (1,200)
2833	Medicinal, Botanical Products	Jame Fine Chemical	Bound Brook	2,200 (1,000)
3544	Special Dies, Tools	Crest Products	Union	2,200 (1,000)
2819	Industrial Inorganic Chemicals	Pennwalt	West Deptford	2,200 (1,000)
3429	Hardware	General Motors	Ewing	2,200 (1,000)
2821	Plastics Material	Graver Company	Newark	2,000 (910)
2819	Industrial Inorganic Chemicals	Old Bridge Chemical	Old Bridge	2,000 (910)
2816	Inorganic Pigments	Heubach	Newark	1,800 (820)
2816	Inorganic Pigments	Nuodex	Piscataway	1,800 (820)
3548	Metalworking Machinery	L-Tec	Piscataway	1,800 (820)
3842	Surgical Appliances and Supplies	Howmedica	Rutherford	1,400 (640)
2819	Industrial Inorganic Chemicals	Kuehne Chemical	South Kearny	1,400 (640)
2819	Industrial Inorganic Chemicals	C. P. Chemicals	Woodbridge	1,400 (640)

TABLE 10-3. NEW JERSEY PLANTS WITH SODIUM HYDROXIDE EMISSIONS BETWEEN 1,000 - 5,000 lb/yr (Continued)

SIC CODE	INDUSTRY	COMPANY	LOCATION	EMISSIONS lb/yr (kg/yr)
2899	Chemical Preparations	Southland Corp.	Great Meadows	1,400 (640)
2818	Industrial Inorganic Chemicals	Givaudan	Clifton	1,300 (590)
2840	Soaps, Cleaners	Dow Consumer Products	Piscataway	1,200 (550)
3611	Electrical Equipment	RCA	Camden	1,200 (550)
2821	Plastics Materials	B. F. Goodrich	Oldmans	1,200 (550)
2951	Paving Mixtures & Blocks	Witco Chemical	Perth Amboy	1,200 (550)
3352	Nonferrous Rolling and Drawing	Easco Corp.	N. Brunswick	1,100 (500)
3341	2° Nonferrous Metals	Johnson Matthey	Winslow	1,100 (500)
3255	Clay Refractories	Certech	Westwood	1,000 (450)
2834	Pharmaceutical Prep.	Hoffman LaRoche	Nutley	1,000 (450)
2810	Industrial Inorganic Chemicals	American Cyanamid	Linden	1,000 (450)
3599	Machinery, Except Electrical	GSM	Pennsauken	1,000 (450)

11.0 NaOH INDUSTRY

11.1 INDUSTRY DESCRIPTION

Table 11-1 shows the 43 plants operating in the United States in 1986 that produce sodium hydroxide (caustic soda). Also, shown in this Table is the process (diaphragm, mercury or membrane) used at each plant. Twenty-five plants have diaphragm cells, 21 plants have mercury cells and 4 plants have membrane cells. Also, some pulp and paper plants produce NaOH as a captive operation. Table 11-2 shows recent changes in capacity for chlor-alkali plants in 1986-87. During this period, there were four expansions and two shut-downs. Table 11-3 provides some historial production of caustic soda in the United States. For the period 1970-85, production for each year was around 10 million short tons and as high as 12.8 million short tons. Most sodium hydroxide is produced as a 50% solution.

11.2 PROCESS DESCRIPTION

11.2.1 General

Sodium hydroxide (caustic soda) is produced by the electrolysis of a sodium chloride (salt) solution via the diaphragm, mercury, or membrane cell. Chlorine and caustic soda are produced concurrently in the electrolytic cells. Chlorine is produced at the anode and sodium hydroxide forms at the cathode of the cell. In the diaphragm-cell plants, the caustic leaves the cells as a dilute solution and is evaporated to either 50 or 73 percent solutions. In mercury cell plants, high purity caustic can be produced in any desired strength and requires no concentration.[2] A description of the three cell processes follows.

11.2.2 Diaphragm Cell Process

Diaphragm cells produce approximately three-fourths of the caustic produced in the U.S.[3] A process flow diagram is shown on Figure 11-1. The input to these cells is normally saturated brine. Brine purification is necessary to prevent plugging of the diaphragm by the precipitation of metal hydroxides.

TABLE 11-1. NaOH PLANTS IN THE UNITED STATES -1986[1]

Plant	Location	Process
Stauffer Chemical Company	LeMoyne, AL	Mercury
Olin Corporation	McIntosh, AL	Diaphragm
Occidental Chemical Corp.	Mobile, AL	Mercury
Occidental Chemical Corp.	Muscle Shoals, AL	Mercury
Dow Chemical USA	Pittsburg, CA	Diaphragm
Dow Chemical USA	Delaware City, DE	Mercury
Olin Corporation	Augusta, GA	Mercury
LCP Chemicals & Plastics, Inc.	Brunswick, GA	Mercury
Brunswick Chemical Company	Brunswick, GA	Diaphragm
General Electric Company	Mt. Vernon, IN	Diaphragm
Vulcan Chemicals	Wichita, KS	Diaphragm, Membrane
B.F. Goodrich Chemical	Calvert City, KY	Mercury
Formosa Plastics Corp. USA	Baton Rouge, LA	Diaphragm
Occidental Chemical Corp.	Convent, LA	Diaphragm
Vulcan Chemicals	Geismar, LA	Diaphragm
Kaiser Aluminum & Chemical Corp.	Gramercy, LA	Diaphragm
PPG Industries, Inc.	Lake Charles, LA	2 Diaphragm, Mercury
Dow Chemical USA	Plaquemine, LA	Diaphragm
Georgia Gulf Corporation	" "	Diaphragm
Stauffer Chemical Company	St. Gabriel, LA	Mercury
Occidental Chemical Corp.	Taft, LA	Diaphragm, Mercury
LCP Chemicals & Plastics, Inc.	Orrington, ME	Mercury
Stauffer Chemical Company	Henderson, NE	Diaphragm
Olin Corporation	Niagara Falls, NY	Diaphragm
LCP Chemicals & Plastics, Inc.	Syracuse, NY	Diaphragm, Mercury
LCP Chemicals & Plastics, Inc.	Acme, NC	Mercury
Fort Howard Paper Company	Muskogee, OK	Membrane
Pennwalt Corporation	Portland, OR	Diaphragm
Olin Corporation	Charleston, TN	Mercury
E.I. duPont deNemours & Co., Inc.	Corpus Christi, TX	Diaphragm
Dow Chemical USA	Freeport, TX	Diaphragm, Mercury
Occidental Chemical Corp.	Deer Park, TX	Diaphragm, Mercury
Occidental Chemical Corp.	LaPorte, TX	Diaphragm
Hercules, Inc.	Hopewell, VA	Diaphragm
Georgia-Pacific Corporation	Bellingham, WA	Mercury
Weyerhaeuser Company	Tacoma, WA	Diaphragm
Pennwalt Corporation	Tacoma, WA	Membrane
LCP Chemicals & Plastics, Inc.	Moundsville, WV	Mercury
PPG Industries, Inc.	New Martinsville, WV	2 Diaphragm, Mercury
Fort Howard Paper Company	Green Bay, WI	Diaphragm
P&G Paper Products Company	Green Bay, WI	Membrane
Vulcan Chemicals	Port Edwards, WI	Mercury

TABLE 11-2. RECENT CHANGES IN CAPACITY AT CHLOR-ALKALI PLANTS (1986-87)[1]

Plant	Location	Project
General Electric Company	Burkville, AL	New Plant - Diaphgram
Brunswick Chemical Company	Brunswick, GA	Membrane cell added
Occidental Chemical Corp.	Taft, LA	Restart 2 cells
DuPont/Olin (joint venture)	Niagara Falls, NY	New Plant - Membrane
DuPont	Corpus Christi, TX	Shut-down entire plant
Dow Chemical USA	Freeport, TX	Partial shut-down

TABLE 11-3. NaOH PRODUCTION IN THE U.S.[1]

Year	Total (10^3 Short Tons)	Liquid 68-74% (10^3 Short Tons)	Liquid - Others (10^3 Short Tons)	Dry (10^3 Short Tons)
1970	10,100	837	8,550	NA
1975	9,630	552	8,800	393
1976	10,500	500	9,760	376
1977	11,000	567	10,100	353
1978	11,300	510	10,400	393
1979	12,800	489	11,700	470
1980	11,600	435	10,800	441
1981	10,600	405	9,980	375
1982	9,380	320	8,740	292
1983	10,000	341	9,430	325
1984	10,900	335	10,400	308
1985	10,800	281	10,500	255

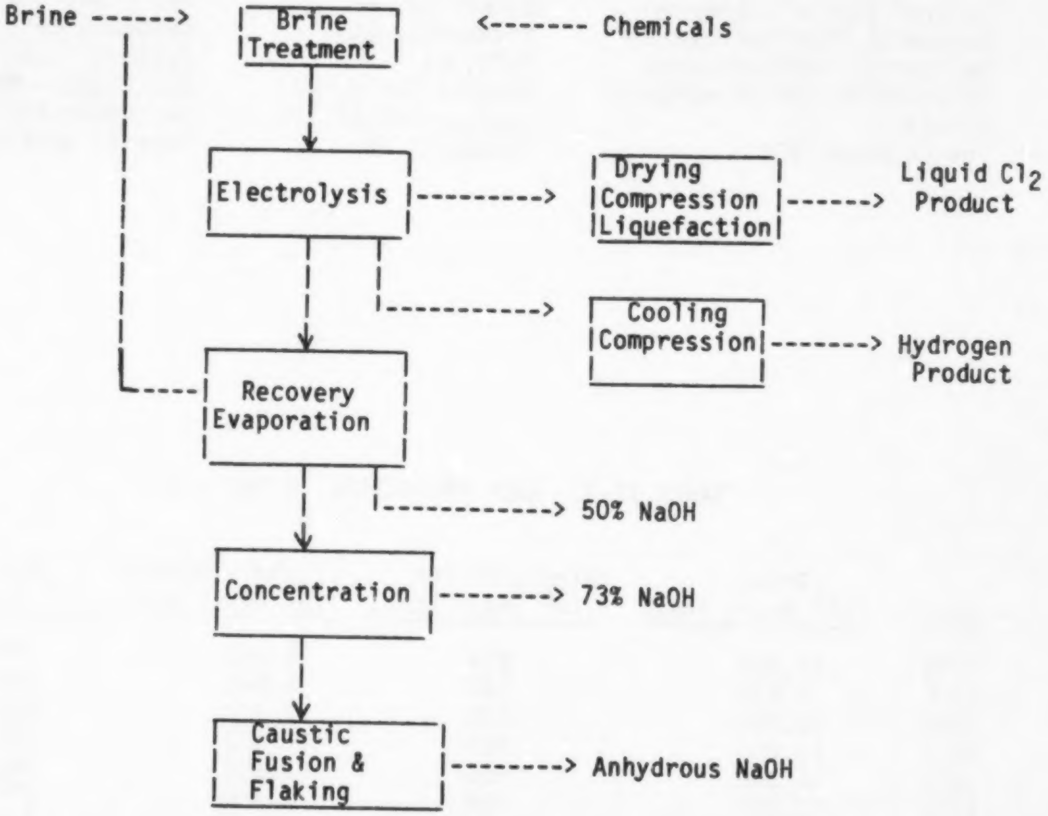

Brine
Brine Treatment
Chemicals
Electrolysis
Drying Compression Liquefaction
Liquid Cl_2 Product
Cooling Compression
Hydrogen Product
Recovery Evaporation
50% NaOH
Concentration
73% NaOH
Caustic Fusion & Flaking
Anhydrous NaOH

Figure 11-1. NaOH Production by the Diaphragm Cell Process

In the brine treatment process, soda ash and caustic are added to adjust the pH to about 10 to precipitate insoluble metal hydroxides such as calcium and magnesium. The brine is then filtered to remove these precipitates.[4,5]

A diagram of a typical diaphragm cell is shown on Figure 11-2. As many as 200 cells are operated in series. In this cell hot (60-70°C), purified, saturated brine is fed continuously to the anode and hot chlorine gas, hydrogen and caustic soda are produced.[5] The following reaction takes place:

$$2\ NaCl + 2H_2O \dashrightarrow 2\ NaOH + Cl_2 + H_2$$

Diaphragm cells consist essentially of three parts; the anode, the cathode and the diaphragm separating the two. The cells are rectangular or cylindrical steel shells supporting graphite or steel screen cathodes. The anode section consists of a concrete bottom holding an assembly of closely spaced graphite blades cast in lead. Extending through the side of the bottom are copper bus bars that conduct current to the lead. The cathode section rests on the concrete bottom and is constructed of a steel plate with a wire screen coated on the anode side with an asbestos diaphragm. The concrete top is sealed to the cathode section. The diaghragm permits the flow of brine between the anode and cathode compartments while preventing contact of the products of the electrolytic decomposition.[5]

The diaphragm cell produces a weak caustic liquor containing about 11 percent caustic and 15 percent sodium chloride. The caustic is concentrated in evaporators to 50 percent and sometimes to 73 percent caustic. During evaporation, excess salt precipitates out and is filtered, washed, and returned to the brine system as a slurry.[5]

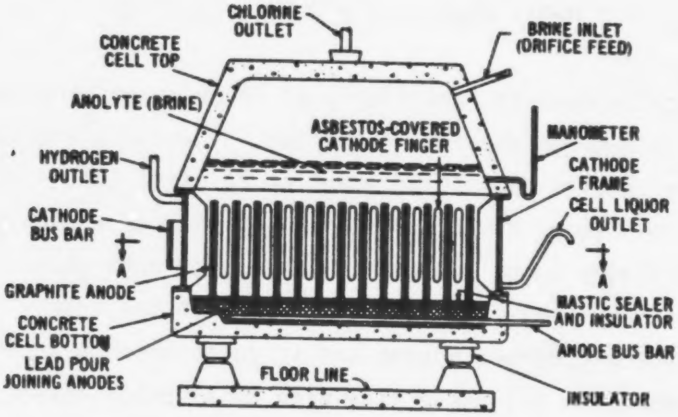

CHLORINE OUTLET
CONCRETE CELL TOP
BRINE INLET (ORIFICE FEED)
ANOLYTE (BRINE)
ASBESTOS-COVERED CATHODE FINGER
MANOMETER
HYDROGEN OUTLET
CATHODE FRAME
CELL LIQUOR OUTLET
CATHODE BUS BAR
A
A
GRAPHITE ANODE
MASTIC SEALER AND INSULATOR
CONCRETE CELL BOTTOM
ANODE BUS BAR
LEAD POUR JOINING ANODES
FLOOR LINE
INSULATOR

Figure 11-2. Diaphragm Cell Used to Produce Sodium Hydroxide and Chlorine[5]

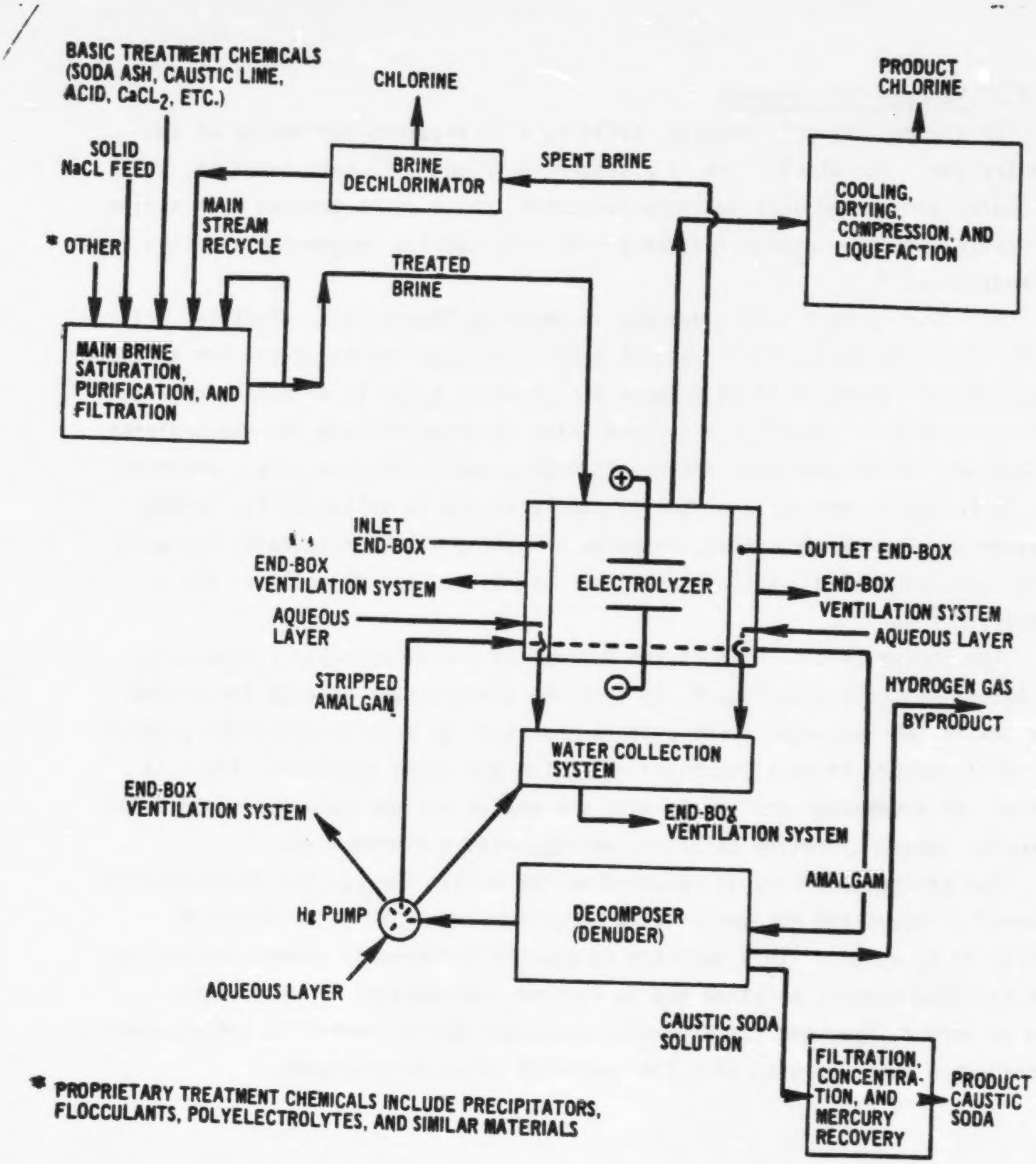
11.2.3 Mercury Cell Process

In the mercury cell process, solid salt is required for makeup of the electrolyte. The electrolyte is a saturated (about 25%) salt solution, which is heated and passed into purification tanks, where it is treated with sodium carbonate and some caustic soda to precipitate calcium, magnesium and iron as hydroxides.[6]

A flow diagram for this process is shown on Figure 11-3. Purified brine is fed from the main brine treatment section through the inlet end box to the electrolyzer, where it flows between a stationary graphite or metal anode and a flowing mercury cathode. The spent brine is recycled from the electrolyzer to the main brine treatment section through a dechlorination step. Chlorine gas is formed at the anode of the electrolyzer and is collected for further treatment. The gas is cooled, dried by scrubbing with concentrated sulfuric acid, and compressed. The dry chlorine gas may be used directly or may be liquified.[7]

The sodium is collected at the cathode of the electrolyzer, forming an amalgam. The sodium amalgam flows from the electrolyzer through the outlet end box to the decomposer, where it is the anode to a short-circuited graphite or metal cathode in an electrolyte of sodium hydroxide solution. Water is fed to the decomposer and reacts with the sodium amalgam to produce elemental mercury, sodium hydroxide solution, and by-product hydrogen gas.

The stripped mercury is returned to the cell. The caustic soda solution generally leaves the decomposer at a concentration of 50 percent sodium hydroxide by weight. This solution is usually filtered to remove impurities. The filtered caustic solution may be further concentrated by evaporation. The by-product hydrogen gas from the decomposer may be vented to the atmosphere, burned as a fuel, or used as a feed material in other processes.[7]


BASIC TREATMENT CHEMICALS (SODA ASH, CAUSTIC LIME, ACID, CaCL2, ETC.)
CHLORINE
PRODUCT CHLORINE
SOLID NaCL FEED
BRINE DECHLORINATOR
SPENT BRINE
COOLING, DRYING, COMPRESSION, AND LIQUEFACTION
* OTHER
MAIN STREAM RECYCLE
TREATED BRINE
MAIN BRINE SATURATION, PURIFICATION, AND FILTRATION
+
INLET END-BOX
OUTLET END-BOX
END-BOX VENTILATION SYSTEM
ELECTROLYZER
END-BOX VENTILATION SYSTEM
AQUEOUS LAYER
AQUEOUS LAYER
−
STRIPPED AMALGAM
HYDROGEN GAS BYPRODUCT
WATER COLLECTION SYSTEM
END-BOX VENTILATION SYSTEM
END-BOX VENTILATION SYSTEM
AMALGAM
Hg PUMP
DECOMPOSER (DENUDER)
AQUEOUS LAYER
CAUSTIC SODA SOLUTION
FILTRATION, CONCENTRATION, AND MERCURY RECOVERY
PRODUCT CAUSTIC SODA

* PROPRIETARY TREATMENT CHEMICALS INCLUDE PRECIPITATORS, FLOCCULANTS, POLYELECTROLYTES, AND SIMILAR MATERIALS

Figure 11-3. NaOH Production by the Mercury Cell Process[7]

The inlet end box is a receptacle that is placed on the inlet end of the electroylzer to provide a convenient connection for the stripped mercury as it returns from the decomposer to the electrolyzer. Also, it keeps the incoming mercury covered with an aqueous layer. The outlet end box is a receptacle that is placed on the outlet of the electrolyzer to provide a convenient means for keeping the sodium amalgam covered with an aqueous layer and for the removal of the thick mercury "butter" that is formed by impurities.[7]

11.2.4 Membrane Cell Process

There is a trend to build new chlor-alkali or replace existing diaphragm or mercury cells with membrane cells. Compared to these cells, the membrane cells are less expensive to build, consume less electricity per ton of product and cost less to operate.[8,9]

A flow diagram for this process is shown in Figure 11-4. The membrane cell can use salt or saturated brine as the raw material. Similar to the other two processes, caustic and soda ash are used to precipitate calcium, magnesium and other metallic ions. In order to maintain membrane life, a second stage treatment is used with ion exchange resins. The treated solution then enters electrolytic cells that produce a 29-33 percent NaOH solution. In the membrane cell, a synthetic cation exchange membrane separates the electrolytic reaction products. As in the diaphragm cell, chlorine gas is generated at one side of the membrane, and caustic soda and hydrogen gas are produced at the cathode side. The membrane allows passage of only the sodium ions from the anode to cathode.[7] This solution is then pumped to a vacuum flash evaporator that raises the NaOH concentration to 40 percent. Vapors from the evaporator are fed to a heat exchanger of the second effect to produce 50 percent caustic soda.[8]

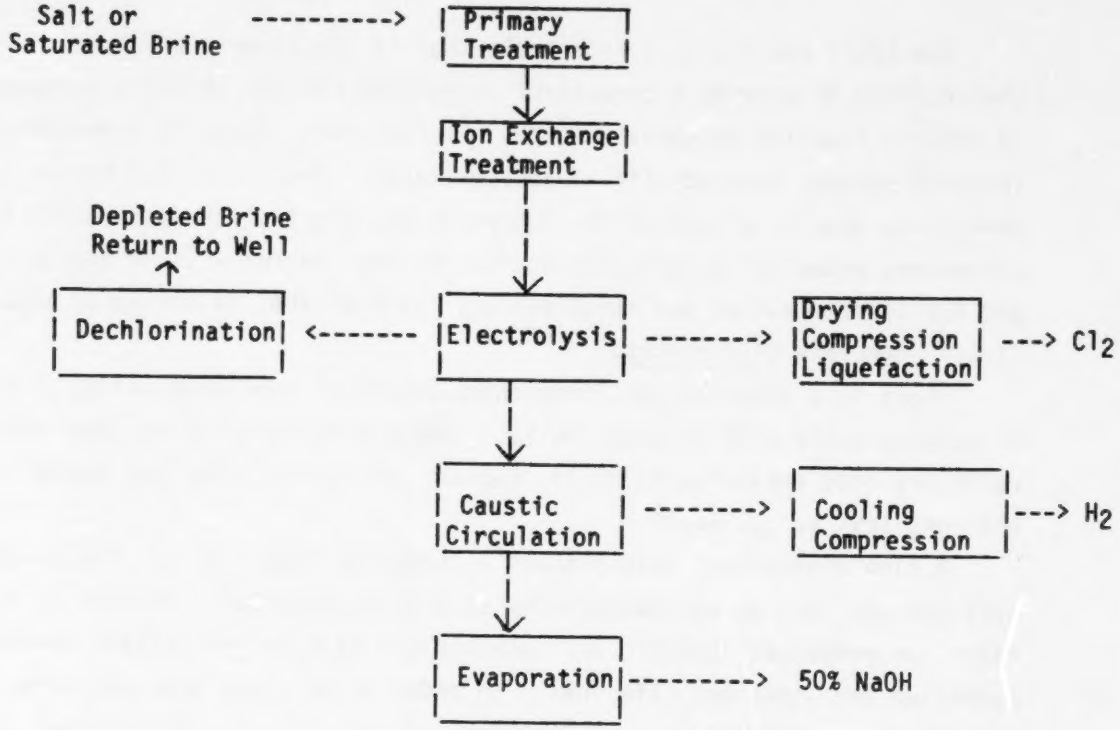

Salt or
Saturated Brine
Primary
Treatment
Ion Exchange
Treatment
Depleted Brine
Return to Well
Dechlorination
Electrolysis
Drying
Compression
Liquefaction
Cl_2
Caustic
Circulation
Cooling
Compression
H_2
Evaporation
50% NaOH

Figure 11-4. NaOH Production by the Membrane Cell Process.[8]

11.3 EMISSIONS (OTHER THAN NaOH)

Emissions from diaphragm and mercury cell processes include chlorine gas, mercury from mercury cells, and carbon dioxide.[5] No information was readily available on emissions from membrane cells. Gaseous chlorine is present in the blow gas from liquefaction and from vents in tank cars, ton containers and cylinders.[5] Uncontrolled chlorine emissions vary from 20-100 lbs/ton of chlorine produced for diaphragm cells and 40-160 lb/ton for mercury cells. Storage and handling results in 33.5 lb/ton for both processes.[10] Control equipment for blow gas from liquefaction include water absorption (94 percent efficiency) and carbon tetrachloride absorption or caustic scrubbing (99.9 percent efficiency).[10]

From the mercury cells, mercury is emitted from the hydrogen by-products stream, the end-box ventilation system and the end-room ventilation air.[7] Control techniques for these processes include cooling, mist elimination, chemical absorption, activated carbon adsorption and molecular sieve adsorption.[7] Using controls, mercury emissions from the hydrogen gas stream ranged from 0.002-2.0 lb/day. Lower emissions were controlled by molecular sieve or carbon adsorption control systems. Highest values are controlled by using a cooling system alone. For the end box ventilation system, mercury emissions range from 0.002 - 0.94 lb/day.[7]

Carbon dioxide is generated in both diaphragm and mercury cells by the oxidation of the graphite anodes. Also, carbonates present in the cold feed brine are decomposed during acidification. Uncontrolled carbon dioxide emissions vary from 40 lbs/ton of chlorine produced for diaphragm cells to 20 lbs/ton for mercury cells.

11.4 NaOH EMISSIONS/HEM INPUTS

Information on sodium hydroxide emissions was obtained on three of the eight chlor-alkali plants located in the four states (Kentucky, New Jersey, New York, Texas) that sent printouts on NaOH emissions. No information was available from any other data source on sodium hydroxide emissions from this industry. This information is summarized on Table 11-4. As shown on this table, sodium hydroxide emissions are minor as estimated by State personnel for the chlor-alkali industry and range from 0 - 25 kg/yr per plant.

A process flow diagram for the sodium hydroxide emission sources at Occidental is shown in Figure 11-5. The plant is presently only operating the diaphragm cells. The centrifuge and filter separate salt and other impurities from the 50 percent caustic soda solution.[11]

Sodium hydroxide emissions from Olin, Niagara Falls, NY, result from the storage and handling of sodium methylate ($NaOCH_3$). This compound is produced using the same type of mercury cell used in the production of caustic soda but is not part of the chlor-alkali plant. The sodium amalgam from the mercury cell is fed to the decomposer with an electrolytic solution of NaOH. Methanol, not water, is fed to the decomposer to produce sodium methylate. The chlorine produced is collected and sent to the chlorine plant. Sodium methylate is used in the production of Vitamin A and other pharmaceuticals as well as serving as a methyl precursor in the manufacture of pesticides and other products.[12]

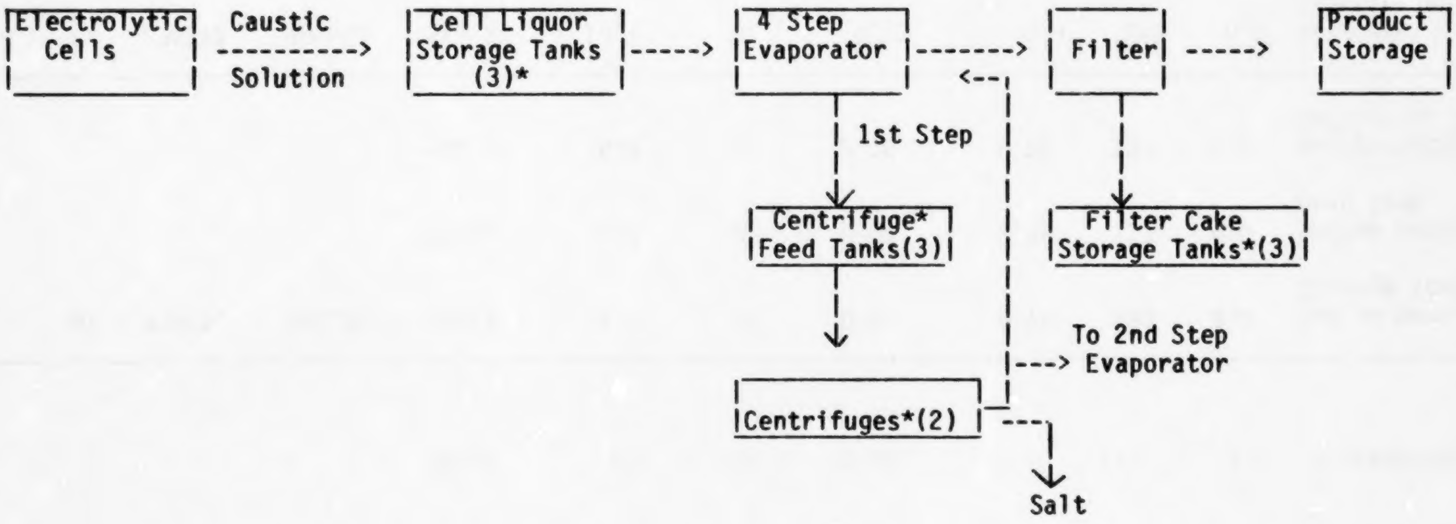

Electrolytic Cells
Caustic Solution
Cell Liquor Storage Tanks (3)*
4 Step Evaporator
Filter
Product Storage
1st Step
Centrifuge* Feed Tanks(3)
Filter Cake Storage Tanks*(3)
To 2nd Step Evaporator
Centrifuges*(2)
Salt

Figure 11-5. Occidental Chemical - Niagara Falls, NY.[11]

* NaOH Emission Sources

TABLE 11-4.

HEM INPUTS FOR SODIUM HYDROXIDE EMISSIONS FROM CHLOR-ALKALI PLANTS

Plant Name	State	Latitude/Longitude (deg, min, sec.)		Emission Type	Stack Height (m)	Cross-Sect Area (m^2)	Stack Dia. (m)	Stack Velocity (m/s)	Stack Temp. (°K)	NaOH Emissions (Kg/yr)	Emission Source	Control Equip.
Occidental Chemical	NY	430502	850225	Stack	25	10	0.30	29.1	289	4	3 Filter Cake Tanks	Spray Tower Scrubber
				Stack	SAME STACK AS ABOVE					8	3 Centrifuge Feed Tanks	Spray Tower Scrubber
				Stack	SAME STACK AS ABOVE					12	3 Cell Liquor Storage Tanks	Spray Tower Scrubber
				Stack	23	10	0.25	13.0	289	1.7	2 Centrifuges	Spray Tower Scrubber
Olin Corp.	NY	430451	850136	Stack	6.7	10	0.05	0.26	323	4.0	Sodium Methylate Storage Tank	None
				Stack	6.4	10	0.05	0.26	333	4.0	Sodium Methylate Feed Tank	None
				Stack	8.2	10	0.05	0.26	333	4.0	Sodium Methylate Collection Tank	None
Occidental Chemical	TX	294342	950643	Stack	10.7	10	0.25	11.3	299	0.0	Anhydrous Caustic Prod.	Caustic Scrubber
				Stack	9.4	10	0.51	12.8	294	0.0	Diaphragm Cell Fugitives	Scrubber

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